



THE SCERP MISSION

The Southwest Consortium for Environmental Research and Policy (SCERP) was established by the U.S. Congress in October 1990 to "initiate a comprehensive analysis of possible solutions to the acute air, water quality, and hazardous waste problems that plague the United States-Mexico border region." SCERP is a consortium of five U.S. universities (Arizona State University, New Mexico State University, San Diego State University, University of Texas at El Paso, and University of Utah) and five Mexican universities (El Colegio de la Frontera Norte, Instituto Tecnológico de Ciudad Juárez, Instituto Tecnológico y de Estudios Superiores de Monterrey, Universidad Autónoma de Baja California, and Universidad Autónoma de Ciudad Juárez). SCERP carries out its mission through a cooperative agreement with the U.S. Environmental Protection Agency. A permanent administration office is maintained by the consortium in San Diego.

ENVIRONMENTAL PROBLEMS OF THE U.S.-MEXICAN BORDER REGION

The border region lies 100 kilometers, or 60 miles, on each side of the U.S.-Mexican political boundary and encompasses parts of four states in the United States—Texas, New Mexico, Arizona, and California—and six Mexican states—Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas. Approximately 13 million people live in the U.S. counties and Mexican *municipios* on the border. The high density of people and increased industrialization since the passage of the North American Free Trade Agreement (NAFTA) have placed an even greater burden on the inadequate infrastructure and environmental resources of the region. Exacerbating the problem is the fact that many U.S. counties along the border are categorized as "economically distressed," and few communities possess the resources needed to address their environmental concerns. Some of the critical border environmental issues include:

- Rapid urbanization and lack of adequate infrastructure
- Air pollution from open burning, vehicle emissions, and industrial operations
- Contamination of surface water and groundwater from open sewers and industrial waste
- Overuse of aquifers and surface streams
- Transportation and illegal dumping of hazardous wastes
- Destruction of natural resources

THE SCERP SOLUTION

SCERP uses a broad, integrated, multidisciplinary approach to address the issues of the border. SCERP researchers collaborate with the U.S. Environmental Protection Agency (EPA) and Mexico's Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), as well as local and state governments, tribal nations, business and industry, non-governmental organizations, and communities of the border region. SCERP organizes research, outreach, and training programs devoted to improving environmental conditions and building capacity in the border region for resolving critical environmental problems. SCERP is pioneering a model of binational cooperation that brings U.S. and Mexican researchers together and introduces new skills and perspectives in binational environmental problem solving.



CONSORCIO DE INVESTIGACION Y POLITICA AMBIENTAL DEL SUROESTE
SOUTHWEST CONSORTIUM FOR ENVIRONMENTAL RESEARCH & POLICY

THE U.S.-MEXICAN border environment:

Binational Air Quality Management

SCERP
14

THE U.S.- MEXICAN border environment: Binational Air Quality Management



Edited by
Ross Pumfrey

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Southwest Consortium for Environmental Research and Policy

THE U.S.-MEXICAN BORDER ENVIRONMENT

Binational Air Quality Management

SCERP Monograph Series, no. 14

A series edited by Paul Ganster

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The Southwest Consortium for Environmental Research and Policy (SCERP) is a consortium of U.S. and Mexican universities dedicated to addressing environmental issues of the U.S.-Mexican border region through applied research, outreach, and regional capacity building.

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Arizona State University
El Colegio de la Frontera Norte
Instituto Tecnológico de Ciudad Juárez
Instituto Tecnológico y de Estudios Superiores de Monterrey
New Mexico State University
San Diego State University
Universidad Autónoma de Baja California
Universidad Autónoma de Ciudad Juárez
University of Texas at El Paso
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Binational Air Quality Management

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No. 11 Dynamics of Human-Environment Interactions

No. 12 Integrated Approach to Defining Particulate Matter Issues
in the Paso del Norte Region

No. 13 Lining the All-American Canal: Competition or Cooperation for
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The views of the authors contained herein are not necessarily the views of SCERP, the U.S. Environmental Protection Agency, or the Secretaría de Medio Ambiente y Recursos Naturales. They are presented in the interest of providing a wide range of policy recommendations to prompt discussion and action in the U.S.-Mexican border region.

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Paul Ganster, San Diego May 2006

SCERP: Promoting a Brighter Future for the U.S.-Mexican Border Region through Sustainability Science

DISCOVERY, LEARNING, AND INNOVATIONS RELATED TO PEOPLE, IDEAS, AND TOOLS

The Southwest Consortium for Environmental Research and Policy (SCERP) (in Spanish Consorcio de Investigación y Política Ambiental del Suroeste, or CIPAS), a collaboration of five U.S. and five Mexican universities located in all 10 border states, assists U.S.-Mexican border peoples and their environments by applying research, information, insights, and innovations. The five American universities are Arizona State University, New Mexico State University, San Diego State University, the University of Texas at El Paso, and the University of Utah. The Mexican universities are El Colegio de la Frontera Norte (COLEF), Instituto Tecnológico de Ciudad Juárez, Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM), Universidad Autónoma de Baja California, and Universidad Autónoma de Ciudad Juárez.

SCERP was created in 1989 and first funded by Congress in 1991 to address environmental issues of the U.S.-Mexican border region and to “initiate a comprehensive analysis of possible solutions to acute air, water and hazardous waste problems that plague the United States-Mexico border region.” Since then SCERP has implemented approximately 400 projects involving as many as 1,000 individuals. Many SCERP students go on to careers in border environmental issues.

The collaboration works closely with the Border XXI and 2012 Programs—which are sponsored by the U.S. Environmental Protection Agency, the U.S. Department of Health and Human

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Services, Secretaría de Medio Ambiente y Recursos Naturales, Secretaría de Salud, and the Integrated Border Environmental Program—and other multi-national organizations. It has the multi-fold mission of applied research, outreach, education, policy development, and regional capacity-building for the communities—the ultimate customers.

SCERP exists to address the rapidly deteriorating border environment, protect and enhance the quality of life and health of border residents, and support the educational mission of our universities. SCERP's vision is a vital region with a dynamic and diverse economy, sustainable environmental quality, intact ecological systems and processes, and a more equitable quality of life.

The approach used by SCERP is to integrate and focus transdisciplinary academic expertise; binational, state, tribal, and local policy-making; non-governmental organization advocacy capacity; and private industry attention and influence on transborder issues.

SCERP informs the decision-making process without advocating for or against a particular position. By interpreting the results of unbiased scientific inquiry, it provides motivation to adopt comprehensive, regional, and long-term policies and solution sets.

SCERP is also the primary sponsor of an annual think tank-style policy conference, called the Border Institute, that convenes 100 top decision-makers and stakeholders from the region to examine complex and critical issues and to recommend policy actions.

CIPAS: Promoviendo un Futuro para la Región Fronteriza México-Estados Unidos a través de la Ciencia Sustentable

DESCUBRIMIENTO, APRENDIZAJE E INNOVACIONES RELACIONADAS CON LAS PERSONAS, IDEAS Y HERRAMIENTAS

El Consorcio de Investigación y Política Ambiental del Suroeste (CIPAS, también conocido como Southwest Consortium for Environmental Research and Policy o SCERP en inglés), una colaboración de cinco universidades estadounidenses y cinco mexicanas ubicadas en los diez estados fronterizos, asiste a las personas fronterizas y a su medio ambiente aplicando investigación, perspicacia e innovaciones. Las cinco universidades norteamericanas son las universidades estatales de Arizona, Nuevo Mexico y San Diego, así como la Universidad de Texas en El Paso, y la Universidad de Utah. Las universidades mexicanas son El Colegio de la Frontera Norte (COLEF), Instituto Tecnológico de Ciudad Juárez (ITCJ), Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM), la Universidad Autónoma de Baja California (UABC) y la Universidad Autónoma de Ciudad Juárez (UACJ).

El CIPAS fue creado en 1989 y fue primeramente auspiciado por el Congreso en 1991 para abordar temas ambientales de la región fronteriza México-Estados Unidos y para “iniciar un análisis comprensivo de posibles soluciones para los problemas acentuados del aire, agua y residuos peligrosos que contaminan la región fronteriza de México-Estados Unidos.” Desde entonces, el CIPAS ha imple-

mentado 400 proyectos involucrando a más de mil individuos. Muchos de los estudiantes del CIPAS se desarrollan profesionalmente en áreas ambientales de la frontera.

La colaboración trabaja conjuntamente con la EPA-HHS-SEMARNAT-SALUD IBEP, y con los Programas Frontera XXI y 2012 así como con otras organizaciones multi-nacionales y tiene una misión amplia de investigación aplicada, educación, desarrollo de políticas, y desarrollo regional de capacidades par las comunidades quienes son nuestros clientes principales.

El CIPAS existe para abordar el problema del rápido deterioro del medio ambiente fronterizo, para proteger y mejorar la calidad de vida y la salud de los residentes de la frontera y para apoyar la misión educativa de nuestras universidades. La visión del CIPAS es de una región vital con una economía diversa y dinámica, calidad ambiental sustentable, sistemas y procesos ecológicos intactos y una calidad de vida más equitativa.

El enfoque utilizado por el CIPAS, es integrar y enfocar la experiencia académica trans-disciplinaria; el proceso de elaboración de política binacional, estatal, tribal y local; la capacidad no gubernamental y de organizaciones interesadas; y la atención privada, e influenciar los factores transfronterizos.

El CIPAS informa al proceso de toma de decisiones sin tomar alguna posición en particular. Al interpretar los resultados de investigaciones científicas imparciales proporciona motivación para implementar políticas y soluciones comprensivas, regionales y de largo plazo.

EL CIPAS también es patrocinador principal de una conferencia anual de política titulada Instituto Fronterizo que reúne a 100 de los mejores tomadores de decisiones y personas interesadas de la región para examinar temas complejos y críticos así como para recomendar acciones de política.

Executive Summary

Proceedings of Border Institute VII: Binational Air Quality Management

ABSTRACT

The Southwest Consortium for Environmental Research and Policy (SCERP) held its seventh annual Border Institute conference in Rio Rico, Arizona, in April 2005. The topic was air quality management in the U.S.-Mexican border region. The conference brought together members of the government, academia, and the private sector. Leaders of the Border 2012 Environmental Program—a binational collaborative effort of the U.S. Environmental Protection Agency (EPA), U.S. Department of Health and Human Services (HHS), the Mexican Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), and the Mexican Secretaría de Salud (Salud)—helped guide and coordinate the conference in order to provide U.S.-Mexican border program partners and participants with advice and recommendations.

With the assistance of papers drafted and distributed prior to the conference, participants identified primary air quality issues in the region, discussed their challenges, and made recommendations.

Recommendations related to transportation and vehicles included the following:

- Identify and remove from the road the relatively small percentage of passenger vehicles that generate the bulk of automotive emissions, the so-called “high emitters”
- Expand existing U.S. diesel retrofit programs to Mexico
- Motivate American and Mexican refineries to produce ultra-low sulfur fuels

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- Electrify truck stops to significantly reduce idling
- Implement a school bus retrofit program for children at risk
- Speed up the handling of commercial and other traffic through ports of entry
- Continue and expand vehicle inspection and maintenance programs
- Prevent the import into Mexico of vehicles without smog inspections
- Plan and provide multiple-modality mass mobility across the border
- Conduct pre- and post-road paving air quality and health surveys
- Upgrade the short-haul, heavy-duty cross-border drayage (back and forth) fleet

Recommendations related to electricity production included the following:

- Bundle energy efficiency and renewable energy projects for funding
- Use U.S. funds to develop renewable energy sources in Mexico for export to the United States
- Create a binational clean air and energy infrastructure trust fund
- Enable cross-border trading of pollutants, emission reductions, and mitigation funds

Other recommendations included the following:

- Develop a permit and notification system for agricultural waste-burning events
- Standardize the air quality index and other data across the border
- Establish a border-wide air quality database
- Set fine particulate matter standards in Mexico
- Expand the Border 2012 Program to include an Energy Task Force
- Move toward official designation of common airsheds
- Institutionalize a formal binational air study group

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- Notify and consult across the borders on significant new emission sources
- Develop and share an annual air quality progress report
- Move toward a binational air quality agreement

INTRODUCTION

A recent National Academy of Sciences/National Research Council study of air quality management (AQM) cited significant progress in decreasing air pollution on nearly all fronts—except on transboundary and interjurisdictional matters. The challenge of managing air quality in border zones remains largely unmet. In April 2005, the Southwest Consortium for Environmental Research and Policy (SCERP), a collaboration of U.S. and Mexican universities that focuses on improving environmental conditions in the U.S.-Mexican border region, held its annual Border Institute policy conference to discuss transboundary AQM.

The 1983 Agreement between the United States of America and the United Mexican States on Cooperation for the Protection and Improvement of the Environment in the Border Area (known as the La Paz Agreement) initiated a process that has become a global model for addressing complex international environmental, ecological, and human health issues. Under that agreement, the U.S. and Mexican federal governments have negotiated successive binational environmental programs. The third and current such program, Border 2012, is a 10-year program that began in 2002. The program has goals and objectives related to air quality, water quality, land contamination, compliance, enforcement, pollution prevention, environmental health, and emergency response. With regard to air quality, it aims to “reduce air emissions and harmful exposure as much as possible in order to attain all respective national ambient air quality standards.”

SCERP organized Border Institute VII in cooperation with the Border 2012 Program and that program’s border-wide Air Policy Forum, with the objective of tapping expertise and ideas from a broad range of sources that could provide advice to Border 2012 participants at all levels. Border Institute VII participants analyzed the most cost-effective and long-term transboundary AQM

strategies for all or parts of the border region. Border Institute VII not only addressed the challenges of today but discussed the difficulties expected to emerge over the next generation. The recommendations of the workshop, included herein, provide a roadmap to cleaner, healthier air in the border region for the next 25 years.

Nobel Laureate Dr. Mario Molina, who was asked by the Mexican government in 1999 to lead a team that addressed air quality problems in Mexico City, provided the keynote address at the conference. He emphasized the importance of understanding how public policy is designed and implemented and explained the decision to focus Mexico City's air quality work on removing the heaviest-polluting vehicles, establishing high standards for air quality, improving mass transit, and introducing ultra-low sulfur fuels. He was optimistic that Mexico would be able to use the global carbon credit system that had been stimulated by the Kyoto Protocol to fund AQM initiatives.

This executive summary outlines the complex factors affecting and resulting from air quality in the border region, provides guidelines for action, and presents scenarios and strategies that may be used to overcome air pollution challenges.

AIR QUALITY: A CONTINUING PROBLEM AT THE U.S-MEXICAN BORDER

This section presents and connects issues of limited resources, demographic and economic growth, agriculture and climate, health consequences, and related factors in the region.

The principal challenges in confronting air quality problems are identifying the specific pollutants posing the greatest health risks, their consequences (mortality, morbidity, and productivity costs), their sources (electricity generation, industrial production, motor vehicles, agriculture, or other activities), as well as developing workable mitigation strategies.

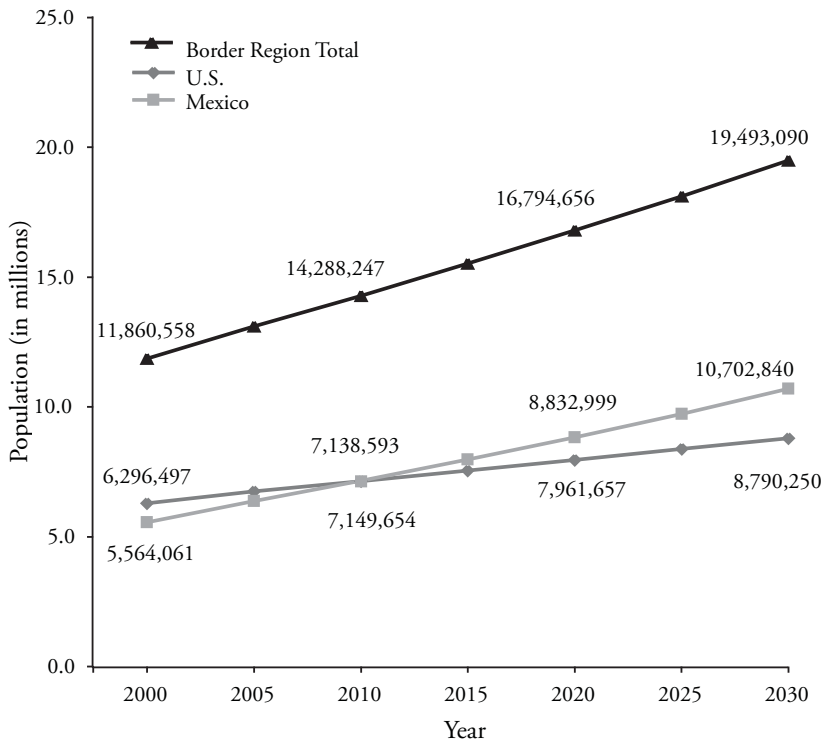
In the border region, air pollution is affected by, among other factors, dramatic population growth, economic activities (including agriculture in some parts of the region), and relative poverty. The population in the border region is expected to double within the

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next 30 years—twice as fast as the Mexican national average and three times faster than in the United States (Figure 1). Economic growth in almost all its forms not only directly generates pollution, but also attracts workers and their families who engage in, or require, numerous other activities potentially generating pollution.

Limited resources affect the technologies chosen by individuals and governments. Many people drive low-cost, older, and, therefore, more polluting vehicles, for example, and governments may only be able to operate outdated automotive inspection and maintenance procedures. Moreover, a lack of resources can also prohibit any response to air quality problems by individuals (with civil lawsuits or better health care) and governments (with energy conservation programs or expanded mass transit). In the U.S. portion of the

Figure 1. Mid-range Border Population Projection



Source: James Peach, New Mexico State University

border region, wages, employment, and tax revenues all tend to be lower than in the rest of the United States and although wages tend to be higher than the Mexican national average on that side of the border, they are still lower than on the U.S. side.

The increased economic activities have not generated tax revenues commensurate with the needs that must be addressed. Rather, economic growth has produced, among other phenomena, increased traffic, congestion at ports of entry, and “energy maquiladoras,” or power plants in Mexico that import natural gas from the United States and export electricity back, skirting U.S. enforcement of ambient pollution standards. Along the same lines, a number of liquefied natural gas (LNG) sites has been proposed, permitted, or is already under construction to provide fuel to the burgeoning border zone and the rest of the United States.

In addition to the effects of limited resources and increased economic activity, climatological and agricultural factors also diminish air quality in the region. The border region is characterized by arid or semi-arid conditions, but irrigation allows an active agricultural sector featuring crops and livestock. The production of both crops and livestock creates dust and other aerosol pollutants through, for example, agricultural waste burning and concentrated animal feeding operations. Finally, portions of the region experience atmospheric temperature inversions and reverse-flow events that capture and concentrate the mix of diurnal and evening pollutants into large and episodic peaks, mostly nocturnal.

The human lung effectively filters 70,000 liters, or 50 pounds, of air every day. Polluted air has several serious human health consequences:

- Immediate effects of oxidative stress and inflammation
- Acute effects such as asthma and respiratory illnesses
- Delayed effects such as heart attacks and strokes
- Chronic effects such as reduced capacity, cancer, tuberculosis, emphysema, and fibrosis

Recently, air pollution has been associated with in utero effects, including birth defects, low birth weight, developmental retardation, and even leukemia. All effects are more pronounced in children’s developing lungs, as well as in elderly and ill individuals.

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At least three additional and aggravating factors complicate air quality:

- Hispanics' genetic predisposition to be more susceptible to certain air pollutants than other groups
- The mobility of populations, which frustrates attempts to assess long-term effects of air pollution sources
- Practices such as open burning

GUIDELINES FOR ACTION

Coordinate Policy on Both Sides of the Border

In the past and even today, authorities on one side of the border often take an action aimed at reducing air pollution and it is not met with a similar effort on the other side. Such unilateral Air Quality Management (AQM) may not produce emission reductions sufficient to meet air quality objectives. Section 179B of the U.S. Clean Air Act recognizes this problem and exempts a border air district from federal regulatory consequences if it has taken significant steps to clean its air but cannot reach attainment due to the pollutants generated from another nation.

An example of delayed but ultimately successful coordination occurred in El Paso and Ciudad Juárez. To reduce carbon monoxide (CO), Texas in 1992 began requiring that only oxygenated fuels be sold in El Paso from October through March, but initially Mexico did not make similar fuel available in Ciudad Juárez. In 1999, Mexico took similar action in response to a request from the air basin's cross-border air quality committee. Thus, CO concentrations subsequently decreased to the extent that El Paso now appears eligible to be redesignated as an attainment area under the U.S. standard.

Road paving and vehicle maintenance are two areas in which cross-border coordination is important to improve air quality. The investment of time, effort, and funding in a cooperative initiative is justified by the significant benefits residents on both sides of the border receive.

Exploit Complementary Benefits

When the reduction of one or more criteria pollutants is attained by increases in conservation, efficiency, or shifts to other fuels, there is almost always a complementary reduction in emissions of carbon dioxide. As a result of the Kyoto Accord's goals for carbon reduction and the agreement's Clean Development Mechanism, international carbon markets have been established that provide a source of financing for projects that will cut or sequester carbon emissions. It follows, therefore, that such funding is also available for projects that simultaneously reduce criteria pollutants. Because Mexico is a Kyoto signatory, projects in that country can take advantage of this emerging market.

Chapter VI points out that of 35 strategies for reducing air pollution in the border region compiled from various sources (including the binational Air Policy Forum under Border 2012), 17 of them also reduce carbon emissions. Carbon market experts estimate that worldwide carbon credits will be worth \$10 billion by 2012.

According to a 2000 RAND report, there is ample opportunity for developing nations like Mexico to reduce greenhouse gas emissions over the next 20 years without sacrificing economic development. Mexico's gross domestic product can continue to grow at a healthy rate while carbon credits provide the incremental revenues necessary to influence new electric power plants to move toward less-polluting technologies and fuels. The North American Development Bank (NADB), the World Bank, and the Inter-American Development Bank all recognize the benefits of reducing criteria pollutants and hazardous toxic air pollutants through investments in renewable fuels and in efficiency on both the supply and demand sides. The last two of those organizations also explicitly recognize the merit of reducing carbon emissions.

Participants in Border Institute VII suggested using these various sources of financing in several specific ways to reduce air pollution. One example is to promote increased use of solar water heaters on roofs—either commercial or residential—as they are a cost-effective, already-available technology. Participants also suggested exploiting renewable resources in northern Mexico, such as solar and wind, for

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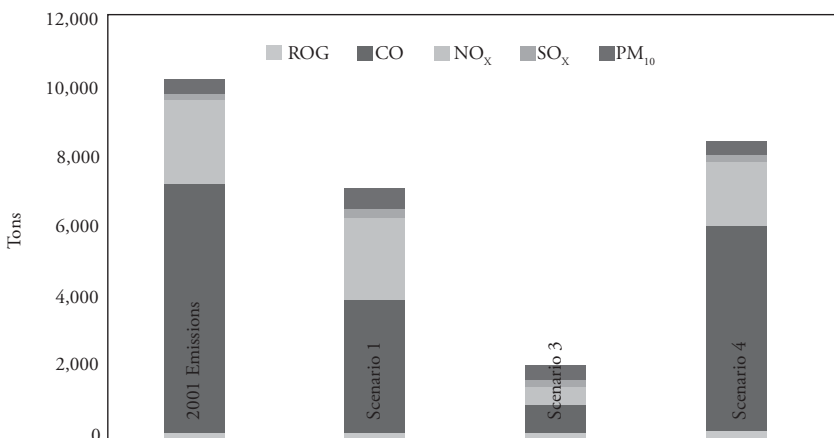
new generation plants that would sell electricity to U.S. utilities and qualify to meet state Renewable Portfolio Standards (state-mandated target levels of generation from renewable sources). Replacing old and inefficient automobiles and appliances such as air conditioners and refrigerators is another strategy.

A recent SCERP project modeled the projected electricity load in the border region and the reductions in air pollution (as well as water use) that could be obtained by building renewable-fueled power plants to replace old plants and also to meet growing demand. The result suggested that future demand can be met by such a scheme. Figure 2 shows the results of several models that plot how to get more energy and better air quality. The region already uses significant geothermal power and has large solar and wind potential, but has tapped almost none of the biomass potential despite the agricultural sector's significant role in many parts of the region.

Nurture Binational Social Infrastructure

Much success in reducing air pollution is attributable to dedicated binational social infrastructure and human capital—a network of stakeholders and institutions that work within their jurisdiction but

Figure 2. Good Energy Planning Can Meet Demand and Still Reduce Emissions



Source: San Diego State University Center for Energy Studies

Binational Air Quality Management

cooperate across local, state, and international borders toward a common goal. Social infrastructure, once developed for one objective, can be leveraged for other objectives.

Excellent examples of binational social capital exist in the border region. In Douglas, Arizona, and Agua Prieta, Sonora, a history of cross-border cooperation, including work by the Arizona-Mexico Commission, helped bring a road-paving proposal to fruition. In Ambos Nogales (the sister cities of Nogales in Arizona and Sonora) a new social infrastructure, based initially on the Border Liaison Mechanism, was successfully developed to promote and implement revegetation efforts. A true test of the strength of this binational social infrastructure is playing out over the Tijuana River as conservationists attempt to restore the riverway while fighting attempts to extend the border fence through the Tijuana River Estuary to the Pacific coast.

A somewhat more formal example of binational social infrastructure was created in the air basin that includes El Paso, Texas; Doña Ana County, New Mexico; and Ciudad Juárez, Chihuahua. During the early 1990s the air basin was in violation of both U.S. and Mexican standards for ozone, particulate matter, and carbon monoxide. The Joint Advisory Committee (JAC) was established in the mid-1990s, under the framework of the La Paz Agreement and includes representatives of U.S. and Mexican federal, state, and local government, as well as representatives from academia, non-governmental organizations, industry, and private citizens. It was loosely modeled after the Los Angeles air basin's South Coast Air Quality Management District (which similarly overlaps several local governmental jurisdictions), but lacks any regulatory authority. JAC promotes cooperation, strategic planning, and advocacy among and by its members.

The single most important JAC accomplishment has been its explicit recognition and declaration that people living in the different governmental jurisdictions share a common air basin. This creates the understanding that the jurisdictions (cities, states, and countries) share joint responsibility for their air quality and that binational coordination is critical.

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Based on the concept of the common air basin, JAC has generated several policy and program successes, including the introduction of oxygenated fuels on both sides of the border and the hemisphere's first experiment with a cross-border, cross-pollution trade in which a company in El Paso was allowed to meet new and tougher state standards for emissions by paying for a reduction in another pollutant in Ciudad Juárez.

JAC has stimulated or supported several other programs that merit review and consideration by other air basins in the border region:

- Congestion mitigation at border crossings through designated commuter lanes
- Improved brick kiln design
- Public education about air quality, including designation of "Ozone Action Days"
- Oxygenated and low vapor-pressure fuels
- Cooperation on identifying and calculating "area" sources for an emission inventory
- "Cash for Clunkers" vehicle buy-out projects

New efforts modeled on the JAC and its success might begin by outlining the magnitude of the problems, developing a clear sense of the urgency, designing a committee membership plan that assures inclusion of all stakeholder groups (as well as a sense of continuity and responsibility), sharing administrative and research functions, and achieving some small, early successes to establish credibility.

Public education on air quality must be based on timely interpretation of relevant ambient air quality data, usually provided by government air pollution control agencies and academic research scientists. Effective pollution regulations that clean the air can create respect and even demand for environmental controls. Effective outreach programs should include active education and involvement of local elected officials, medical doctors, and school teachers, all of whom should—but often do not—know the health effects of air pollution and ways to reduce exposure.

The "Molina Effect"—the influence wielded by a respected and visible spokesperson who can focus public interest on an issue—is invaluable when the subject is as technical, complicated, and

politically challenging as AQM. Such a person may be, like Dr. Molina, a highly credible scientist who has the capacity to speak in understandable terms to media and politicians about the most relevant data, risks, and mitigation policies or programs. The policies and programs should include something with a relatively short-term tangible result, because political support for AQM tends to decline unless benefits are realized quickly after investment.

Use Scenario Planning as Policy Development Tool

Scenario planning (envisioning an alternate future and using that picture to inform policy decisions today) can help identify and prioritize among different policy options by modeling their effects over time. Costs, benefits, and unintended but predictable consequences can be evaluated. Beneficiaries of a particular action on one or both sides of a border can be identified, motivating the coordination of bilateral activities.

Scenario planning typically compares the future implied by the status quo to hypothetical scenarios in order to highlight steps to more desirable outcomes. “Business as usual” is typically the first scenario to be analyzed. The SCERP-authored challenge paper for Border Institute VII (summarized herein) presents seven other scenarios and more than 30 strategies for air quality improvement.

Each scenario contains various strategies, defined as tangible, measurable activities within one or more scenarios. For example, within the mobile sources scenario, the diesel emissions reduction project is a particularly effective strategy. The effort to upgrade the diesel fleet in Mexico with clean fuels, catalytic converters, and exhaust filters addresses an identified problem, is cost-effective, and can be implemented with a known source of funds. One model is the Carl Moyer Memorial Air Quality Standards Attainment Program funding in California, under which that state’s Air Resources Board gives an incentive for the incremental cost of cleaner-than-required engines and equipment.

With respect to measurements of cost-effectiveness, it is important to recognize that in the border region, synergisms and complementary benefits are especially important considerations.

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Several criteria are important in guiding sound policy. While some of these are the same as those used to evaluate traditional pollution control strategies—degree of mitigation, external benefits, feasibility—strategies must succeed on a number of levels. Economic progress must be as sustainable as possible; thus, pollution mitigation policies must not adversely affect labor or the overall economic health of the region. Flexibility is also an asset of any strategy. Not only should plans be geographically flexible to allow for replication in various areas of the border, they must also be adaptable as conditions change. As an example, vehicle inspection and maintenance (I&M) (including smog checks and associated vehicular smog equipment efficacy) programs must be designed to address the principal pollutants of today and tomorrow. Because generation of a large quantity of pollutants in the border zone is related to personal behaviors, public understanding of the strategies is also important. Officials must explain the costs, benefits, and goals of each policy. Only with an informed and cooperative public will policies aimed at increasing the availability and use of public transportation or decreasing open burning, for instance, truly succeed.

Increased enforceability of existing and new legislation and resolutions will be crucial to future policy success. One traditional pollution control strategy—vehicle inspections—has improved recently but remains difficult to enforce because tampering with pollution mitigation devices is nearly impossible to stop. If a strategy is not enforceable, the public will not support it, financial and environmental impacts will be skewed, and mitigation benefits will decrease. Enforceability is perhaps the most important criterion for evaluation of strategies.

In a region where discrepancies in wealth from one side of the border to the other are so great, equitable policy solutions are critical. One segment of the population or side of the border should not suffer any extra environmental or financial costs from mitigation policies intended for general benefit. Residents on the Mexican side of the border have suffered inequitable protection as U.S. energy companies move their plants to Mexico to avoid strict

U.S. ambient air quality and emissions regulations while still selling the electricity produced to U.S. consumers at a competitive price. Mexican residents realize little environmental or economic benefit.

SCENARIOS AND STRATEGIES

Using scenario planning to identify the best possible policy options today for the most desirable outcomes tomorrow, Border Institute VII developed a set of recommended strategies for managing air quality in the border region.

Scenario I: Modernized Transportation System/Improved Public Mobility

Problem: EPA and SCERP estimate that as few as 10% of all vehicles in the United States emit the same amount of pollution as the remaining 90% of vehicles. The ratio is different in Mexico, where lower incomes result in a greater dependence on old cars.

Strategy: Revitalize “Cash for Clunkers” programs, especially on the Mexican side, where I&M programs have lower budgets. The greatest “super-emitters” can be easily identified by visual inspection. Removing them upon discovery or purchase would be highly beneficial. This project could use regional EPA AQM funds.

Problem: Diesel vehicles emit some of the dirtiest and most harmful pollutants. Starting in 2007, the United States, and not Mexico, will have much tougher emission requirements for new diesel engines. The United States is also requiring that ultra-low-sulfur fuel, which is required for the newer technology to work properly, be made available. The new engines will likely be sold worldwide. At this point, Mexico recently announced its intent to produce ultra-low-sulfur fuel but has not yet made final decisions.

Strategy: Mexico should provide the necessary financing for Petróleos Mexicanos (or Pemex, the country’s oil monopoly) to produce ultra-low sulfur fuel, at least for selected border-related transportation corridors, or should allow the import of such fuel

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from the United States into Mexico. Alternative fuels of all kinds—including biodiesel—ought to be used to effect the greatest emissions reduction from diesel vehicles.

Problem: It will take between 20 years and 30 years for the existing truck fleet to fully turn over after the introduction of new diesel engines in 2007, and so there is still a major challenge to address with the existing fleet.

Strategy: U.S. states should continue and expand existing grant programs that facilitate owners of existing trucks retrofitting their engines (retrofit devices such as catalytic converters and soot filters are becoming more available for older model diesel vehicles), such as the Carl Moyer Fund in California, and Mexico should continue and expand its Diesel Emission Reduction Collaborative (DERC). Ultra-low-sulfur fuel is also needed for the retrofit technology.

Problem: Diesel truck drivers usually leave their engines idling at truck stops, even when they are stopping to sleep, in order to provide power for air conditioning and various appliances (including refrigeration of cargo). This generates a significant amount of pollution. Although diesel engines beginning with the 2007 model year will emit dramatically less, the long turnover period for the existing fleet makes it necessary to address this challenge now.

Strategy: Governments on both sides of the border should promote and provide subsidies for the electrification of truck stops, port of entry inspection stations, and border maritime ports. Technology that allows trucks to hook up to the grid at truck stops is already commercially available and in use, but promotion and accelerated adoption are needed. Using electricity rather than diesel engines will not only reduce the net pollution emitted but will also save truck companies money on engine wear and tear. Studies have shown that investments in reduction of diesel emissions have a high ratio of health benefits to cost, and so reasonable subsidies are justified.

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Problem: Significant consequences of the North American Free Trade Agreement (NAFTA) have been increased regional trade, increased border crossings by border residents, and the movement of products and produce from maquiladoras (factories) and farms in Mexico to customers in the United States. But both the short-haul drayage fleet and long-haul trucks are slowed by lengthy inspections and security checks at the border. Programs aimed at addressing this problem (“smart” ports of entry and Fast Pass/SENTRI/Frequent Commuter Lanes/EZPass) have been stalled.

Strategy: The U.S. Department of Homeland Security should speed up traffic at ports of entry. Programs to do so have significant economic and environmental benefits. When special lanes are part of a program, they should incorporate a preference for the cleanest vehicles, including those that have passed inspection and maintenance scrutiny.

Problem: Too few I&M programs exist, and those that do, fail to fully motivate vehicle maintenance that ensures the best operating, and therefore the least polluting, vehicles.

Strategy: Governments should continue all I&M programs on the U.S. side and implement new I&M programs on the Mexican side, targeting municipal vehicles first. The standards should be graduated inversely to the age of the vehicle on the Mexican side so that compliance can be affordable and, thus desirable to the public.

Problem: U.S. car owners often sell their used (and therefore older, less efficient, and sometimes uninspected) vehicles to Mexicans. In addition, new car dealers in Mexico actively prohibit import of vehicles newer than 10 years old, thus exacerbating the bifurcation of the Mexican market.

Strategy: Mexico should prevent the import of old, unfit vehicles into the country by requiring that customs officials demand a smog inspection from the state of export, and by allowing newer vehicles to be imported.

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Problem: Planning of transportation infrastructure often breaks down at the border where one jurisdiction ends and another begins. The extra coordination necessary to ensure continuous and efficient flow of materials, people, and products in the border region is lacking. As a result, the border has long suffered marginalization of services common in other areas. Basic rail service, for example, exists in only a few locations along the border.

Strategy: Governments and private stakeholders should plan and provide mass transit across the border, including transit for commuters in identifiable groups, such as students and shoppers headed for particular venues. Further, all border and port-of-entry agencies should coordinate rail, road, air, and marine planning processes across the border and with various air, transportation, and planning agencies.

Problem: Many products from the interior of Mexico are off-loaded from long-haul trucks and then loaded onto a short-haul drayage fleet that, because of its duties, is not as well maintained as the longer-haul trucks.

Strategy: Convert and upgrade the drayage fleet to modern standards. A recently passed California law (AB 1009) can serve as a model for implementing this strategy.

Scenario II: Renewable Energy Sources and Efficient Use

Problem: Many facilities in the border zone use energy in ways that are technically and economically inefficient. Cost-effective improvements could save significant amounts of electricity and fuels and thereby reduce air pollution. The inefficiencies exist in industrial processes, space heating and cooling, and various appliances and technologies (such as pumps, fans, and motors).

Strategy: A two-part strategy is recommended. First, governments should encourage public and private managers to adopt aggressive “environmental management system” practices, including audits that identify opportunities for cost-effective improvements in efficiency. Government assistance can take the form of regulatory incentives,

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workshops, and technical assistance, and the latter two approaches can be cross-border. The Texas Commission on Environmental Quality, for instance, should revive its impressive EPA-funded program of technical assistance to maquiladoras in neighboring states, and other states should emulate the example. Second, and to address the problem of scale and financing, interested private sector firms (including energy service companies) should “bundle” into bankable loan proposals a number of otherwise independent site-specific opportunities at various companies or projects. Sources of financing could include NADB, and Mexican projects could additionally use carbon credits developed to take advantage of the Kyoto Protocol’s Clean Development Mechanism. As an extension of this strategy (especially in Mexico), governments should be proactive with new projects. For example, Mexico’s Federal Electricity Commission (CFE), working with the National Commission for Renewable Energy (CONAE), could survey proposed large, low-income housing projects for opportunities to adopt energy efficiency up front.

Problem: The border region has very good solar energy resources, includes pockets of very good wind energy resources, and has numerous solid waste landfills whose long-term production of methane could support electricity generation. In many cases, these resources are proximate to the grid, and yet the potential is largely untapped. One of the challenges is the incremental cost of production.

Strategy: The U.S. Congress should extend the production tax credit for renewable fuel energy generation for several more years. In Mexico, the government and the private sector should cooperate in identifying and obtaining sources of financing to cover the incremental costs, such as carbon credits and the World Bank’s Global Environmental Facility.

Problem: Although the U.S. and Mexican governments have established grant funds at NADB for projects related to water, wastewater, and solid waste in the border region in order to

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complement NADB's loan funds, there is no similar grant funding available at NADB for projects related to renewable energy, energy efficiency, or other efforts that would reduce air pollution.

Strategy: The U.S. and Mexican governments should expand the availability of grant funds at NADB to include renewable energy, energy efficiency, and other projects that would reduce air pollution.

Problem: Even if LNG ports and regasification facilities that make the fuel available for local use were built in Mexico, there is little distribution system in Mexican cities.

Strategy: The Mexican government should require LNG port builders to build the distribution system for use by local residents.

Scenario III: Engaged Market Forces

Problem: The United States has no mechanisms to allow crossborder trading of pollutants, offsets, emission reduction credits, and mitigation funds (with the exception of a narrowly constructed state-based program in Texas), even though these mechanisms may provide the greatest returns on investments in pollution reduction.

Strategy: U.S. federal and state lawmakers should establish such market incentives as part of State Implementation Plans as they pertain to border areas. This should be accomplished first through state legislation (similar to the Texas law that allowed the El Paso-Ciudad Juárez pollutant trade), and then through amendments to the Clean Air Act. Mexican law already allows for such trades via Articles I-III and III-XI of the General Law of Ecological Equilibrium and Protection of the Environment (often referred to as LGEEPA, its acronym in Spanish) as well as Articles III-IV and III-V of the Federal Air Regulation.

Problem: The commercial banking system does not adequately address the significant opportunities that exist for projects related to alternative energy technologies.

Strategy: Governments and foundations should enhance existing efforts to provide revolving loan funds, including microloans, for cost-effective investments that reduce air pollution, especially through energy technologies. This should include a binational microlending program that provides loans for the electrification of truck stops. Such a program could be funded by border-crossing tolls, environmental impact fees (funds available from development), or transportation taxes.

Scenario IV: Improved Natural/Area/Agricultural Source Controls

Problem: Agricultural burns create pollutants that not only affect households or communities in the immediate vicinity, but also the air quality in other airsheds, including those that span the border.

Strategy: Assuming there are no alternatives to agricultural burns, regulatory agencies should limit the health risks and other negative consequences by developing permit systems that include conditions and notification requirements. On days when exceedances of standards are predicted, for example, “no burn” days should be enforced.

Problem: Currently, the Border Environment Cooperation Commission (BECC) reviews and certifies and NADB extends loans to road-paving projects as a strategy to reduce air pollution, but the conditions and requirements lack rigor with respect to the following important factors:

- Planning the best roads to pave (which has been based in some cases simply on which streets residents or business owners are willing to pay)
- Knowing how much dust is being prevented from re-suspension
- Assessing pre- and post-project health consequences
- Following up with road sweeping programs to maintain decreased dust levels

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Strategy: As road-paving proposals are being developed, BECC should provide criteria-based selection and technical guidance related to traffic counts, air quality, and health surveys before and after the projects. As well, BECC should include street sweeping or wetting as a required follow-up activity. New road programs should be financed by tolls.

Scenario V: Enhanced Data Collection, Analysis, and Outreach

Problem: Governmental agencies that collect and/or analyze air quality or health impact data are not making those data readily available for public education and use by the community. A related data issue in several parts of the border region is that real-time data are insufficiently available or are provided through an inadequate interface. Researchers are often confounded by a lack of universality and quality assurance.

Strategy: Government agencies that have air quality data must give greater consideration to the needs of the public and stakeholder groups. Several approaches are advisable. The first step should be developing and standardizing an air quality index along both sides of the border so everyone speaks the same language when discussing air quality conditions. There is also a clear need for a targeted campaign to educate politicians, health care professionals, and education officials on the dangers of air pollution so they may communicate such health risks to their constituents. Several Border 2012 entities—the Environmental Health Working Group, the Indicators Task Force, and Communications Task Force—could be particularly effective in addressing this problem.

Problem: Governmental agencies that collect and/or analyze air quality or health impact data are not making those data available in a fashion that is optimally useful for analysis. Researchers confront several challenges: access is difficult, the format or presentation of the raw data is unclear or inconsistent, data are often not presented bilingually, information regarding why and how certain data were collected either does not exist or does not appear with corresponding data, and real-time data are often unavailable.

Strategy: To ensure data is both available and optimally useful, a binational committee should be formed to propose to the two federal governments and the states what data are needed and in what format they would be most useful.

PRIORITIES AMONG THE SCENARIOS FOR NEAR-TERM ACTION AT THE FEDERAL LEVEL

Many of the above recommendations cannot be implemented without the active participation of the U.S and Mexican federal governments. At least four actions should be taken in the near term:

- The United States and Mexico should encourage the development of new, renewable and conservation-based energy technologies in border-wide and regional air quality discussions under Border 2012
- Recognizing legitimate issues of sovereignty, Mexico and the United States, along with the 10 border states, should find ways to create transborder airshed management solutions
- Mexico and the United States should officially designate binational common airsheds based on topography, meteorology, and health
- The United States and Mexico should provide grant funding for a Binational Clean Air Trust that can help defray the costs of a transition to technologies that result in less air pollution

Incremental Unilateral and Collaborative Efforts Can Bring Success

Effective improvement of border air quality is an increasingly complex problem and, as such, requires action by a variety of government entities. Some of the recommendations made by Border Institute VII advise only unilateral action by an agency on one side of the border; others require bilateral agreement.

At Border Institute VII, Allen Olson, former governor of North Dakota and a member of the International Joint Commission (IJC) between the United States and Canada, explained that IJC had 80 years of experience addressing cross-border issues when it decided to

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tackle air quality. The social infrastructure was mature. Fifteen years after initial discussions, the U.S.-Canada Air Quality Agreement (AQA) was signed in 1991.

Likewise, the United States and Mexico have experience in developing binational water agreements dating back to 1889. Additionally, they have experiences over the past 10 years with incremental unilateral and collaborative efforts to improve air quality. These efforts, both unilateral and binational, have had beneficial results in selected subregions. These experiences provide a foundation for moving ahead on efforts such as the recommendations of Border Institute VII. Border 2012 can play an important role by providing the mechanisms and leadership to launch efforts to improve air quality.

Although the U.S.-Mexican relationship lacks certain elements that may have facilitated U.S.-Canada interactions—similar levels of economic development and a similar cultural and legal history—citizens, many politicians, educators, and air quality and environmental health professionals recognize that the air quality problems in several portions of the U.S.-Mexican border region are serious and require collaborative action. Incremental efforts combined with progress toward a binational air quality agreement are essential to ensuring a clean environment and a positive economic future.

Many of the recommendations made herein require only unilateral action, and most of them have a history that predates Border Institute VII. At the conference, for instance, SEMARNAT's Director General for Air Quality Management Sergio Sánchez reported that Mexico has recently announced its intent to provide ultra-low-sulfur this year for gasoline vehicles and in 2008 for diesel vehicles. Part of the incentive for Pemex to convert refineries—a several billion dollar undertaking—is its desire to sell fuel to U.S.-licensed trucks making long hauls into Mexico. However, Pemex is taxed very heavily by the federal government and has few resources available for investment.

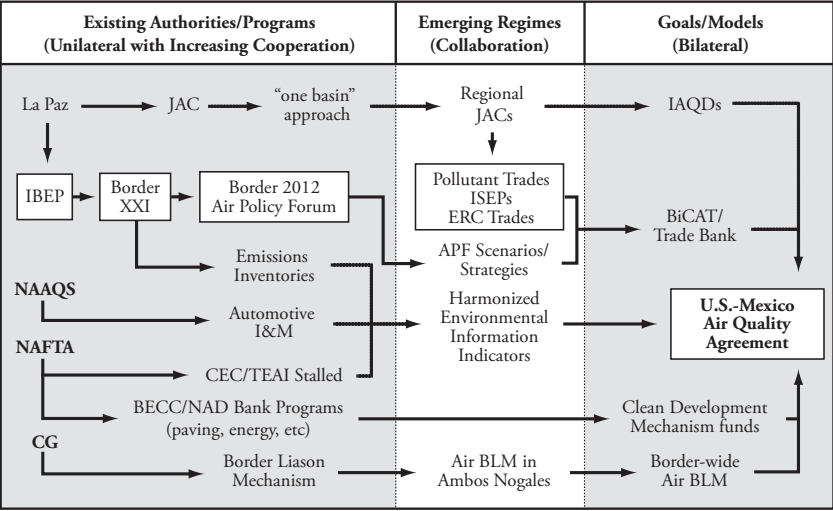
Figure 3 outlines a possible process to reach a U.S.-Mexican AQA. It begins with the La Paz Agreement and its successive implementing programs: the Integrated Border Environmental Plan (IBEP), Border XXI in the late 1990s, and Border 2012 now. The

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current iteration has an Air Policy Forum, a mechanism to coordinate actions across government levels as well as with health authorities. The La Paz Agreement also enabled JAC, which has promoted the one-basin philosophy that enables selected trading of pollutants.

Similar interjurisdictional advisory committees exist both with the facilitating power of the Consul Generals’ Border Liaison Mechanisms (BLM), as in Ambos Nogales, and without facilitating authority, as in the Mexicali-Imperial Valley. BLMs allow local governments to negotiate and arrive at agreement on solution sets that are later endorsed by the respective federal governments in lieu of having to pass each negotiating step up to and across at the federal level. Both those subregions are now covered by Border 2012 Air Task Forces and are moving slowly but surely in the direction of becoming international air quality districts (IAQDs), even if they are not currently authorized by any current state, federal, or local regulations. A bill proposed in California would establish a JAC-like body with its Mexican neighboring state and would also move toward obtaining IAQD status.

Figure 3. A Path to a U.S.-Mexican Air Quality Agreement



Source: Author

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NAFTA institutions have been slow to address air quality issues. While the Commission for Environmental Cooperation (CEC) is stalled on Transboundary Environmental Impact Assessments (TEIAs), BECC has certified and NADB has funded a number of air and energy projects. An air project grant fund (or an emissions trading bank) to complement the water and wastewater Border Environment Infrastructure Fund (BEIF) could be hosted by NADB.

The Kyoto Clean Development Mechanism (CDM), the United Nations, the Global Environment Facility (GEF), and the EPA Methane-to-Market programs offer incentives and potential funding sources for projects related to improving air quality. Concurrently, unilateral but coordinated efforts are under way to characterize air pollution sources and ambient air quality along the border. The private sector is also playing a role. Vehicles are being improved and power plants are being built with more advanced technologies that reduce emissions.

Significant progress has been made to date in addressing air quality issues in the U.S.-Mexican border region, including coordination on technical activities such as monitoring, modeling, and data availability. There are at least three important next steps:

- Institutionalize a formal binational air science study group
- Notify and consult across the border on significant new air emissions and on-going nuisance emissions (agricultural burns) and their impacts
- Develop and share individual nation status and progress reports

Protecting air quality in the U.S.-Mexican border region is too important to delay action on these recommendations generated by Border Institute VII. Degradation of that air quality is likely if the current course of action is maintained. While significant progress has been made at several levels of government, air quality needs to be on the agenda of every border effort and binational initiative, especially those that address energy and water. The sooner the topic of air quality and its associated environmental health impacts are raised and addressed at the highest levels, the more likely it will be

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that air quality and human health are improved and unnecessary international tensions avoided, averting conflicts over this ultimately resolvable problem that, in fact, has a solution.

Resumen Ejecutivo

Memorias del VII Instituto Fronterizo: Gestión Binacional de la Calidad del Aire

RESUMEN

El Consorcio de Investigación y Política Ambiental del Suroeste (CIPAS), llevó a cabo su séptima conferencia anual del Instituto Fronterizo en abril de 2005 en Río Rico Arizona. El tema fue la gestión de la calidad del aire en la región fronteriza México-Estados Unidos. La conferencia reunió a miembros del gobierno, del sector académico y del sector privado. Líderes tanto del Programa Frontera 2012—una colaboración binacional de la Agencia de Protección Ambiental de los Estados Unidos (EPA, por sus siglas en inglés)—, el Departamento de Salud y Servicios Humanos de los Estados Unidos (HHS, siglas en inglés), la Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) y la Secretaría de Salud (S.S.) de México, ayudaron a conducir y coordinar la conferencia para poder proporcionar sugerencias y recomendaciones a los socios de México y los Estados Unidos participantes de programas fronterizos.

Con la asistencia de documentos previamente elaborados y distribuidos, los participantes pudieron identificar varios temas centrales con respecto a la calidad del aire en la región, discutir los retos que existen en atender los mismos y después hacer recomendaciones.

Entre las recomendaciones relacionadas con el transporte de vehículos se incluyeron las siguientes:

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- Identificar y retirar de las calles el porcentaje relativamente pequeño de vehículos que genera la mayor parte de las emisiones automotrices los llamados “grandes emisores”
- Extender hacia México los programas actuales estadounidenses de la modificación/actualización del diesel
- Motivar a las refinerías mexicanas y estadounidenses para que produzcan combustibles de sulfuro ultra bajo
- Electrizar las paradas de camiones para poder reducir de manera significativa la actividad del motor
- Implementar un programa de modificación/actualización de camiones escolares para niños en riesgo
- Acelerar el trámite del tráfico comercial y de otra clase en los puertos de entrada
- Continuar y aumentar los programas de verificación vehicular y de mantenimiento
- Impedir la importación a México de vehículos sin inspección del smog
- Planificar y proporcionar la movilidad masiva en modalidades múltiples a través de la frontera
- Llevar a cabo encuestas en el área de la salud y de la calidad del aire antes y después de la pavimentación de calles
- Actualizar la flota de camiones de recorridos cortos y de carga pesada que cruzan la frontera en ambas direcciones

Dentro de las recomendaciones relacionadas con la generación de la electricidad se incluyeron las siguientes:

- Conglomerar los programas de eficiencia de energía y de la energía renovable para su financiamiento
- Utilizar fondos estadounidenses para desarrollar fuentes de energía renovable en México para ser exportados a los Estados Unidos
- Crear un fideicomiso binacional para la infraestructura de energía y de aire limpio
- Permitir el intercambio transfronterizo de fondos para la reducción y mitigación de contaminantes y de emisiones

Otras recomendaciones incluyeron las siguientes:

- Desarrollar un sistema de permisos de notificaciones para eventos relacionados con la quema de desechos agrícolas
- Estandarizar el índice de la calidad del aire así como otra información a través de toda la frontera
- Establecer una base de datos sobre la calidad del aire a lo largo de la frontera
- Establecer estándares de materia particulada fina en México
- Ampliar el programa Frontera 2012 para que incluya un grupo de trabajo sobre la energía
- Avanzar hacia la designación oficial de cuencas de aire comunes
- Institucionalizar un grupo binacional formal de estudio sobre el aire
- Notificar y consultar a de lo largo las fronteras en cuanto a fuentes nuevas significativas de emisiones
- Desarrollar y compartir un informe anual de progreso de la calidad del aire
- Avanzar hacia un acuerdo binacional sobre la calidad del aire

INTRODUCCIÓN

Un estudio reciente de la Academia Nacional de las Ciencias/Consejo de Nacional de Investigación sobre la gestión de la calidad del aire, (AQM por sus siglas en inglés), citó un progreso importante en la reducción de contaminantes del aire en casi todos los frentes—excepto en cuestiones transfronterizas e interjurisdiccionales—el reto de gestionar la calidad del aire en las zonas fronterizas en gran parte sigue sin ser superado. En abril de 2005, el Consorcio de Investigación y Política Ambiental del Suroeste (CIPAS), una colaboración de universidades mexicanas y estadounidenses que se enfocan en mejorar las condiciones ambientales en la región fronteriza México-Estados Unidos, llevó a cabo su conferencia anual del Instituto Fronterizo para discutir la AQM transfronteriza.

El acuerdo de 1983 entre los Estados Unidos Mexicanos y los Estados Unidos de América sobre la Cooperación para la Protección y el Mejoramiento del Ambiente en la Zona Fronteriza (conocido

como el Acuerdo de La Paz) inició un proceso que se ha convertido en un modelo global para tratar temas complejos internacionales ambientales, ecológicos y de la salud humana. Bajo ese acuerdo, los gobiernos federales de México y de los Estados Unidos han negociado programas binacionales sucesivos en materia ambiental. El tercer y actual programa, Frontera 2012, es un programa de 10 años que comenzó en el año 2002. El programa tiene metas y objetivos relacionados con la calidad de aire, la calidad del agua, contaminación de los suelos, cumplimiento, aplicación, prevención de la contaminación, salud ambiental y respuesta a emergencias.

En lo que respecta a la calidad del aire, pretende reducir lo más que se pueda las emisiones al aire y las exposiciones dañinas para poder lograr todos los estándares respectivos ambientales nacionales de la calidad del aire.

El CIPAS organizó el VII Instituto Fronterizo en cooperación con el Programa 2012 y su Foro de Política del Aire existente en la toda la frontera, con el objetivo de aprovechar los conocimientos de expertos e ideas de una amplia gama de fuentes que podría proporcionar consejos a los participantes de todos los ámbitos del Programa Frontera 2012. Los participantes del VIII Instituto Fronterizo analizaron las estrategias transfronterizas del AQM más redituables y de largo plazo para algunas partes o para toda la región fronteriza. En la conferencia no sólo se discutieron los retos actuales sino también las dificultades que se espera surjan en la próxima generación. Las recomendaciones del grupo de trabajo, incluidas aquí, proporcionan un mapa que conduce a un aire más limpio y saludable en la región fronteriza para los próximos 25 años.

El Dr. Mario Molina, laureado con el Premio Nobel, quien fue solicitado en 1999 por el gobierno mexicano para liderar a un grupo que abordó los problemas de la calidad del aire en la Ciudad de México, pronunció el discurso principal de la conferencia. Enfatizó la importancia de conocer el diseño y la implementación de la política pública, y explicó la decisión de enfocar el trabajo de la calidad del aire de la Ciudad de México en retirar los vehículos más contaminantes, establecer altos estándares para la calidad del aire, mejorar el transporte masivo e introducir combustibles de sulfuro

ultra bajo. Fue optimista en que México podría utilizar el sistema global de crédito de carbono fomentado por el Protocolo Kyoto para financiar las iniciativas de la AQM.

Este resumen ejecutivo delinea los factores complejos que afectan y resultan de la calidad del aire en la región fronteriza, proporciona directrices de acción, y presenta escenarios y estrategias que podrían utilizarse para superar los retos presentados por la contaminación del aire.

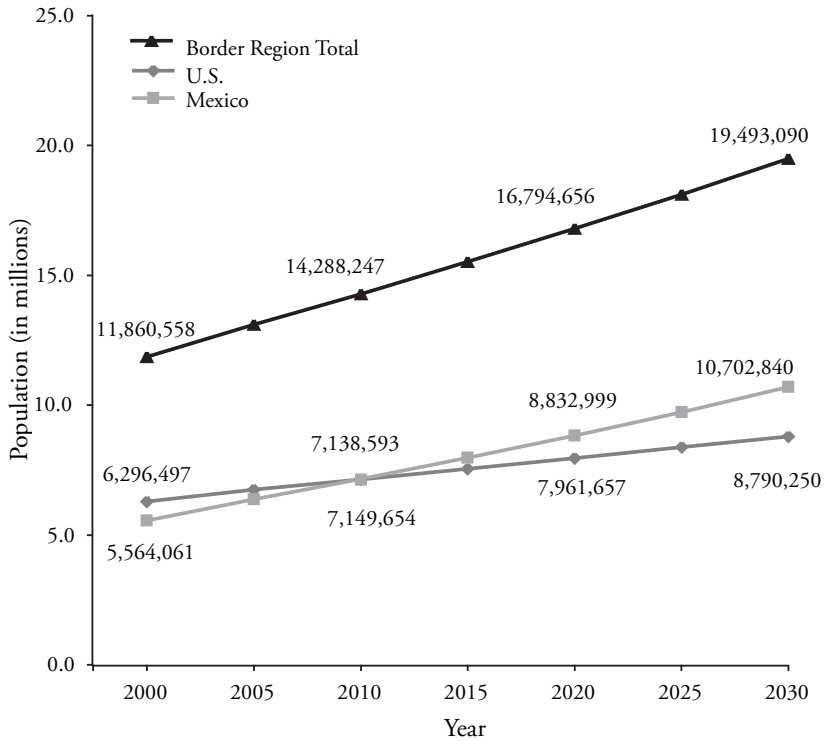
CALIDAD DEL AIRE: UN PROBLEMA CONTINUO EN LA FRONTERA MÉXICO-ESTADOS UNIDOS

Esta sección presenta y une temas de recursos limitados, del crecimiento económico y demográfico, de la agricultura y del clima, de las consecuencias en la salud y de factores relacionados en la región.

Los retos principales para confrontar los problemas de la calidad del aire son identificar los contaminantes específicos que están causando los riesgos más grandes a la salud y sus consecuencias (costos por mortalidad, morbilidad, y la productividad) y sus fuentes (generación de electricidad, producción industrial, vehículos motorizados, agricultura u otras actividades), así como estrategias factibles de mitigación.

En la región fronteriza, la contaminación del aire es afectada, entre otros factores, por el dramático crecimiento poblacional, las actividades económicas (incluyendo la agricultura en algunas partes de la región) y la pobreza relativa. Se espera que la población en la región fronteriza se duplique en los próximos 30 años—dos veces más rápido que el promedio nacional en México y tres veces más rápido que el de los Estados Unidos—(Figura 1). El crecimiento económico en casi todas sus formas no sólo genera directamente la contaminación, sino que al mismo tiempo atrae a trabajadores y sus familias quienes participan en, o requieren de, otras numerosas actividades que generan potencialmente la contaminación.

Figura 1. Proyección de Rango Medio de la Población



Los recursos limitados afectan a las tecnologías que los individuos y los gobiernos escogen. Por ejemplo, muchas personas conducen vehículos viejos, de un bajo costo y, por lo tanto, más contaminantes y los gobiernos quizá sólo pueden realizar inspecciones vehiculares y procedimientos de mantenimientos obsoletos. Más aun, la falta de recursos también puede prohibir cualquier respuesta en cuanto a los problemas de la calidad del aire por los individuos (con demandas civiles o mejor atención médica) y los gobiernos (con programas de conservación de energía o con una expansión de transporte masivo). En la parte estadounidense de la región fronteriza, los sueldos, el

empleo y los ingresos fiscales tienden a ser más altos que el promedio nacional de México en ese lado de la frontera, aún son más bajos que los del lado de los Estados Unidos.

El incremento de las actividades económicas no ha generado ingresos fiscales en proporción con las necesidades que deben ser atendidas. Por el contrario, el crecimiento económico ha producido, entre otros fenómenos, un incremento en el tráfico, congestionamiento en los puertos de entrada y “maquiladoras de energía” o plantas de energía en México que importan gas natural de los Estados Unidos y exportan electricidad de regreso, esquivando la aplicación de los estándares ambientales establecidos. En el mismo orden de ideas, un número de sitios de gas natural licuado (GNL), ha sido propuesto, autorizado o se encuentra en construcción, con el propósito de proveer combustible a la floreciente zona fronteriza así como al resto de los Estados Unidos.

Aunados a los efectos de los recursos limitados y al incremento de actividades económicas y los factores climatológicos y agrícolas también reducen la calidad del aire en la región. La región fronteriza se caracteriza por condiciones áridas o semi áridas; no obstante, la irrigación permite un activo sector agrícola de cultivos y ganado. La producción de ambos aerosoles —el cultivo y ganado— genera polvo y otros contaminantes por la quema de desechos agrícolas y operaciones concentradas de alimentación del ganado, por citar algunos ejemplos. Finalmente, partes de la región tienen inversiones de temperatura atmosférica y eventos de flujos inversos que capturan y concentran la combinación de contaminantes diurnos y matutinos en grandes y episódicos horarios pico por lo general nocturnos.

El pulmón humano filtra eficientemente 70,000 litros ó 50 libras, de aire diariamente. El aire contaminado tiene varias consecuencias graves en la salud humana:

- Efectos inmediatos de estrés oxidativo e inflamación
- Efectos agudos tales como el asma y enfermedades respiratorias
- Efectos retardados tales como ataques cardíacos y apoplejías
- Efectos crónicos tales como el cáncer, tuberculosis, enfisema y fibrosis

Recientemente, la contaminación del aire ha sido asociada con los efectos en el útero, incluyendo defectos congénitos, bajo peso al nacer, retraso y hasta leucemia. Todos los efectos son más pronunciados en los pulmones en desarrollo de los niños, así como en las personas de la tercera edad y enfermos.

Por lo menos otros tres agravantes factores complican la calidad del aire:

- Una predisposición genética de la comunidad Hispana a ser más susceptible a algunos contaminantes del aire que otros grupos
- La movilidad de las poblaciones la cual que frustra los intentos de evaluar los efectos a largo plazo de las fuentes de contaminación del aire
- Prácticas como la quema abierta

LAS PAUTAS PARA TOMAR ACCIÓN

Coordinar la Política en Ambos Lados de la Frontera

En el pasado e incluso hoy día, las autoridades en un lado de la frontera a menudo toman una acción con el propósito de reducir la contaminación del aire, y esta acción cuenta con un esfuerzo similar en el otro lado de la frontera. Esta AQM es unilateral y podría no producir suficientes reducciones de emisiones para cumplir los objetivos de la calidad del aire. La Sección 179B de la Ley de Aire Limpio de los Estados Unidos, reconoce este problema y exenta a un distrito fronterizo de aire de las consecuencias reglamentarias federales. Si éste ha tomado medidas significativas para limpiar su aire, pero no ha podido lograrlo debido a los contaminantes generados en otro país.

Un ejemplo de coordinación, aunque retrasada pero finalmente exitosa, ocurrió en El Paso y Ciudad Juárez. Para reducir el monóxido de carbono (CO), a partir de 1990 Texas requirió que sólo combustibles oxigenados podrían ser vendidos en El Paso de octubre a marzo, pero al principio México no hizo disponible un combustible similar en Ciudad Juárez. En 1999, México tomó una acción similar sobre la calidad del aire en respuesta a una solicitud

del comité transfronterizo de la cuenca del aire. Por lo tanto, las concentraciones de CO se redujeron subsecuentemente al grado que El Paso parece ser elegible para ser redesignado como área de obtención bajo los estándares estadounidenses.

La pavimentación de calles y el mantenimiento de vehículos son dos áreas en las cuales la coordinación transfronteriza es muy importante para mejorar la calidad del aire. La inversión de tiempo, esfuerzo y financiamiento en una iniciativa cooperativa es justificada por los beneficios significantes que reciben los residentes de ambos lados de la frontera.

Aprovechar los Beneficios Complementarios

Cuando la reducción de uno o más contaminantes criterio es lograda por un incremento en la conservación, eficiencia o cambios por otros combustibles, existe casi siempre una reducción complementaria de emisiones de dióxido de carbono. Como resultado de las objetivos del Acuerdo de Kyoto para la reducción de carbono así como el Mecanismo de Desarrollo Limpio, se han establecido mercados internacionales de carbono que proporcionan una fuente de financiamiento para proyectos que reduzcan o aislen las emisiones de carbono. Por lo tanto, tal financiamiento de igual manera está disponible para proyectos que simultáneamente reducen contaminantes criterio. Ya que México es signatario del Acuerdo de Kyoto, sus proyectos pueden aprovecharse de este mercado emergente.

El capítulo VI señala que de las 35 estrategias para reducir la contaminación del aire en la región fronteriza, y recopiladas de varias fuentes (incluyendo el Foro de Política de Aire de el Programa Frontera 2012), 17 de éstas también reducen las emisiones de carbono. Los expertos en los mercados de carbono estiman que los créditos mundiales de carbono tendrán un valor de \$10 billones de dólares para el año 2012.

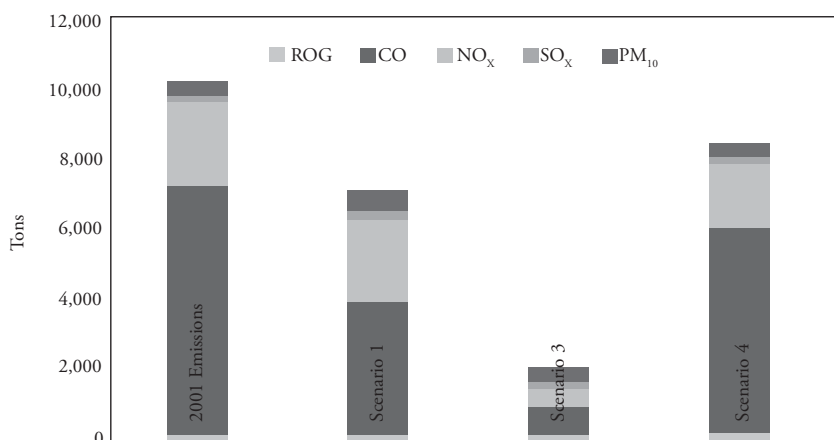
De acuerdo con un informe de RAND del año 2000, existe amplia oportunidad para que las naciones en vías de desarrollo, tales como México, reduzcan las emisiones de gas del efecto invernadero en los próximos 20 años sin sacrificar el desarrollo económico. El producto interno bruto de México puede continuar creciendo a un ritmo sano

mientras que los créditos de carbono proporcionan las ganancias incrementales necesarias para influir a las nuevas plantas de energía eléctrica que utilicen tecnologías y combustible menos contaminantes. El Banco de Desarrollo de América del Norte (BDAN), el Banco Mundial y el Banco de Interamericano de Desarrollo reconocen los beneficios de reducir los contaminantes criterio y los contaminantes peligrosos y tóxicos del aire a través de inversiones en combustibles renovables y en la eficiencia tanto en el lado de la oferta como en el lado de la demanda.

Los participantes en el VII Instituto Fronterizo sugirieron utilizar estas diversas fuentes de financiamiento de varias maneras específicas para reducir la contaminación del aire. Un ejemplo es fomentar un mayor uso de calefactores solares de agua en los techos—ya sea comerciales o residenciales—debido a que son de tecnología costo redituables. Los participantes también sugirieron explotar recursos renovables en el norte de México, tales como solares y eólicos, para plantas nuevas de generación que pudieran vender electricidad a las empresas estadounidenses y calificar para cumplir con los Estándares del Portafolio Renovable (niveles objetivo de energía proveniente de fuentes renovables establecidos por mandato estatal). Otra estrategia es el reemplazar los automóviles y aparatos viejos e ineficientes como los acondicionadores de aire y refrigeradores.

Un proyecto reciente del CIPAS modeló la carga de electricidad proyectada en la región fronteriza y las reducciones de los contaminantes del aire (así como del uso del agua) que podrían ser obtenidas mediante la construcción de plantas de energía de combustible renovable para reemplazar a las plantas antiguas y también satisfacer a la creciente demanda. El resultado sugirió que la demanda futura puede ser satisfecha a través de tal esquema. La Figura 2 muestra los resultados de diversos modelos que delinean cómo obtener mayor energía y mejor calidad del aire. La región ya utiliza significativa energía geotérmica y tiene un gran potencial solar y eólico, pero casi no ha aprovechado ningún potencial de la biomasa a pesar de la función importante del sector agrícola en numerosas partes de la región.

Figura 2. Una buena planificación de la energía puede satisfacer la demanda y aun así reducir las emisiones



Fortalecer la Infraestructura Social Binacional

Gran parte del éxito de reducir la contaminación del aire puede ser atribuido a la infraestructura social binacional y al capital humano dedicado—una red de personas interesadas e instituciones que trabajan dentro de su jurisdicción pero que cooperan a través de las fronteras a nivel locales, estatales e internacionales por una meta común, la infraestructura social, una vez desarrollada hacia una meta, puede ser aplicada para otros objetivos.

En la región fronteriza existen ejemplos excelentes de capital social binacional. En Douglas, Arizona, y Agua Prieta, Sonora, los antecedentes de una cooperación transfronteriza, incluyendo el trabajo de la Comisión Arizona-México, ayudó a que una propuesta de pavimentación de calles se realizara. En Ambos Nogales (las ciudades hermanas en Sonora y Arizona) se desarrolló exitosamente una infraestructura social nueva, basada inicialmente en el Mecanismo de Enlace Fronterizo, para promover e implementar esfuerzos de revegetación. Una verdadera prueba de la fuerza de esta infraestructura social se está dando en el Río Tijuana al intentar los

conservacionistas restaurar el cauce del río mientras que luchan contra los intentos de extender el cerco fronterizo a través del Estuario del Río Tijuana hacia la costa del Pacífico.

Un ejemplo un tanto más formal de una infraestructura social binacional fue creado en la cuenca de aire que incluye a El Paso (Texas), el Condado de Doña Ana (Nuevo Mexico) y Ciudad Juárez (Chihuahua). A principios de la década de los 1990, la cuenca de aire violaba los estándares tanto de México como de los Estados Unidos en lo que respecta al ozono, materia particulada, y monóxido de carbono. El Comité Consultivo Conjunto (JAC, por sus siglas en inglés), se estableció a mediados de la misma década bajo el marco del Acuerdo de La Paz. Incluye representantes de los gobiernos federales, estatales y locales de México y de los Estados Unidos, así como representantes de la academia, organizaciones no gubernamentales, industria y ciudadanos privados. Fue modelado en parte basado en el Distrito de Administración de la Calidad del Aire de la Costa Sur de la cuenca de aire de Los Ángeles, el cual similarmente traslapa diversas jurisdicciones gubernamentales locales. El JAC promueve la cooperación, planeación estratégica y abogacía para y entre sus miembros.

El único y más importante de los logros del JAC es su reconocimiento explícito y declaración de que las personas que viven en las diversas jurisdicciones gubernamentales, comparten una cuenca de aire común. Esto crea un entendimiento de que las jurisdicciones (ciudades, estados y países) comparten una responsabilidad conjunta con respecto a su calidad del aire y por lo tanto una coordinación binacional es crítica.

Basado en el concepto de una cuenca de aire común, el JAC ha generado varias políticas y programas de éxito, incluyendo la introducción de combustibles oxigenados en ambos lados de la frontera y el primer experimento en el hemisferio con un comercio transfronterizo, de transcontaminación en donde a una compañía en El Paso se le permitió observar estándares estatales nuevos y más rigurosos para emisiones, pagando por una reducción en otro contaminante en Ciudad Juárez.

El JAC ha estimulado o apoyado varios otros programas que ameritan análisis y consideración por otras cuencas de aire en la región fronteriza:

Resumen Ejecutivo

- Mitigación de la congestión en los cruces fronterizos a través de líneas designadas
- Diseño modernizado de los hornos de ladrillo
- Educación pública sobre la calidad del aire, incluyendo la designación de “Días de acción de ozono”
- Combustibles oxigenados y de baja presión de vapor
- Cooperación para identificar y calcular las fuentes del “área” para un inventario de emisiones
- Proyectos para la compra de vehículos destartalados conocidos como “Cash for Clunkers”

Los nuevos esfuerzos modelados en el JAC y su éxito podrían comenzar por delinear la magnitud de los problemas, desarrollar un sentido claro de la urgencia, diseñar un plan para un comité de membresía que asegure la inclusión de todos los grupos de personas interesadas (así como un sentido de continuidad y responsabilidad), compartir funciones administrativas y de investigación y lograr pronto algunos pequeños éxitos para establecer la credibilidad.

La educación pública sobre la calidad del aire debe basarse en una interpretación oportuna de información relevante de la calidad del aire ambiente, usualmente proporcionada por los distritos del gobierno sobre el control de la contaminación del aire e investigadores científicos académicos. Las regulaciones efectivas de la contaminación que limpian el aire pueden crear respeto y hasta demanda para controles ambientales. Los programas efectivos de difusión deberían de incluir educación activa y participación de funcionarios locales electos, médicos y profesores de escuelas, quienes deberían conocer—pero por lo general no es así—los efectos que la contaminación del aire tiene sobre la salud y las maneras para reducir su exposición.

El “Efecto Molina”—la influencia ejercida por un vocero respetado y visible que puede enfocar el interés público sobre un tema—es invaluable cuando el tema es tan técnico, complicado y con un reto político tal como el de la gestión de la calidad del aire. Tal persona puede ser, como el doctor Molina, un científico sumamente creíble que tiene la capacidad para hablar con términos comprensibles por los medios de comunicación y políticos sobre la información más relevante, riesgos, y políticas o programas de

mitigación. Las políticas y programas deberían incluir algo con un resultado tangible y de corto plazo ya que el apoyo político para la AQM tiende a relativamente decrecer al menos de que los beneficios se recuperen inmediatamente después de la inversión.

Utilizar la Planeación de Escenarios Como una Herramienta para el Desarrollo de Políticas

La planeación de escenarios (visualizar un futuro alternativo y utilizar esa imagen para informar las decisiones de políticas hoy en día) puede ayudar a identificar y priorizar entre opciones diferentes de políticas a través de un modelado de sus efectos en el transcurso del tiempo. Se pueden evaluar los costos, beneficios y consecuencias no intencionadas pero predecibles. Se pueden identificar los beneficiarios de una acción particular en uno o ambos lados de la frontera, motivando la coordinación de actividades bilaterales.

La planeación de escenarios típicamente compara el futuro que el status quo supone con escenarios hipotéticos para poder destacar los pasos para obtener resultados más deseables. El continuar trabajando como de costumbre, típicamente es el primer escenario que se analiza. El documento de retos desarrollado por el CIPAS para el VII Instituto Fronterizo (resumido aquí), presenta otros siete escenarios y más de 30 estrategias para mejorar la calidad del aire.

Cada escenario contiene diversas estrategias, definidas como actividades tangibles que se pueden medir dentro de uno o más escenarios. Por ejemplo, dentro del escenario de fuentes móviles, el proyecto de reducción de emisiones de diésel es una estrategia particularmente efectiva. El esfuerzo de actualizar la flota de diésel en México con combustibles limpios, convertidores catalíticos y filtros para escapes de emisiones aborda un problema identificado, es costo-efectivo y puede ser implementado con una fuente conocida de fondos. Un modelo es el financiamiento en California del Programa Carl Moyer para la obtención de los Estándares de la Calidad de Aire mediante el cual el Consejo de Recursos Atmosféricos de ese estado proporciona un incentivo por el costo incrementado al realizar una limpieza superior a la requerida de motores y equipos.

Con respecto a las medidas de costos redituables, es importante reconocer que en la región fronteriza la sinergia y beneficios complementarios son consideraciones especialmente importantes.

Diversos criterios son importantes para guiar las políticas sensatas. Mientras que algunas de éstas son igual que aquellas usadas para evaluar las estrategias tradicionales para el control de la contaminación—grado de mitigación, beneficios externos, factibilidad— las estrategias deben ser exitosas en varios niveles. El progreso económico debe ser lo más sustentable posible; por lo tanto, las políticas de mitigación de la contaminación no deben de afectar adversamente la fuerza laboral o la salud económica general de la región. La flexibilidad también es un valor agregado en cualquier estrategia. Los planes no sólo deben ser geográficamente flexibles para permitir su réplica en diversas áreas de la frontera, sino que también deben poder adaptarse a las condiciones cambiantes. Como un ejemplo de inspección y de mantenimiento vehicular (incluyendo los programas de inspecciones de smog y la eficacia asociada con el equipo de smog vehicular) deben ser diseñados para abordar los contaminantes principales del presente y del futuro. Debido a que la generación de una gran cantidad de contaminantes en la zona fronteriza está relacionada con comportamientos personales, el entendimiento público de las estrategias también es importante. Las autoridades deben explicar los costos, beneficios y metas de cada política. Sólo con un público informado y cooperativo podrán ser verdaderamente exitosas las políticas que pretenden incrementar la disponibilidad y uso del transporte público o reducir la quema abierta por ejemplo.

Una mayor ejecución de nuevas leyes y resoluciones será crucial para futuros éxitos de políticas. Una estrategia tradicional de control de la contaminación—inspecciones vehiculares—ha mejorado recientemente, pero su ejecución sigue siendo difícil ya que es casi imposible frenar la modificación indebida de los dispositivos que mitigan la contaminación. Si una estrategia no es aplicable, el público no la apoyará, los impactos financieros y ambientales se desviarán y los beneficios de la mitigación se reducirán. La ejecución probablemente es el criterio más importante en la evaluación de las estrategias.

En una región en donde son tan grandes las discrepancias en la riqueza de un lado de la frontera con respecto al otro, son críticas las soluciones equitativas de políticas. Un segmento de la población o de un lado de la frontera no debe padecer de ningunos costos financieros y ambientales adicionales por políticas de mitigación destinadas para el bien común. Los residentes del lado mexicano de la frontera han sufrido de una protección inequitativa a consecuencia de la instalación de las plantas de energía estadounidenses para evadir los estrictos estándares estadounidenses de la calidad del aire ambiente y de emisiones mientras continúan vendiendo la electricidad producida a los consumidores estadounidenses a un precio competitivo. Los residentes mexicanos logran pocos beneficios ambientales o económicos.

ESCENARIOS Y ESTRATEGIAS

Mediante el uso de la planeación de escenarios para identificar las mejores opciones de posibles políticas hoy día para obtener los mejores resultados el día de mañana, el VII Instituto Fronterizo desarrolló una serie de estrategias recomendadas para la gestión de la calidad del aire en la región fronteriza.

Escenario I: Sistema de Transporte Modernizado/Movilidad Pública Mejorada

Problema: La EPA y el CIPAS estiman que un 10% de todos los vehículos en los Estados Unidos emiten la misma cantidad de contaminación que la emitida por el 90% de vehículos restantes. La proporción es diferente en México, en donde los bajos ingresos resultan en una mayor dependencia más alta de vehículos viejos.

Estrategia: Revitalizar los programas de Efectivo por Vehículos Destartalados, especialmente en México, en donde los programas de inspección y mantenimiento tienen presupuestos menores. Los “súper emisores” más grandes pueden ser identificados con facilidad por medio de una inspección visual. El retirarlos una vez identificados o al comprarlos pudiera ser muy beneficioso. Este proyecto pudiera utilizar fondos regionales de la AQM de la EPA.

Problema: Los vehículos que utilizan diésel emiten algunos de los contaminantes más sucios y dañinos. A partir del año 2007, los Estados Unidos tendrá requisitos mucho más rigurosos en lo que respecta a las emisiones de motores nuevos de diésel. Los Estados Unidos también está requiriendo la disponibilidad de combustible de sulfuro ultra bajo, el cual se requiere para que la tecnología más nueva funcione correctamente. Es probable que los nuevos motores se vendan mundialmente. Recientemente México anunció su intención de producir combustible de sulfuro ultra bajo pero aún no ha tomado decisiones finales al respecto.

Estrategia: México debe proporcionar el financiamiento necesario para que Petróleos Mexicanos (PEMEX, monopolio de petróleo en el país) produzca combustible de sulfuro ultra bajo por lo menos para corredores selectos de transporte con relación a la frontera, o debe permitir la importación de tal combustible desde los Estados Unidos hacia México. Combustibles alternativos de toda clase— incluyendo biodiésel— deberían ser utilizados para efectuar la mayor reducción de emisiones provenientes de vehículos diesel.

Problema: Tomará de 20 a 30 años para que el camión de carga existente produzca un cambio después de presentar y aplicar los nuevos motores diesel en el 2007, por lo tanto existe aun un gran reto para abordar el tema con la flota existente.

Estrategia: Los estados norteamericanos deberán continuar y expandir los programa existente de fondos que facilitan que los dueños de camiones de carga modifiquen/actualicen sus motores (actualización de dispositivos tales como catalizadores filtros de hollín están más disponibles para modelos actuales de vehículos diesel), tales como el Fondo de California Carl Moyer, y México debería de continuar y expandir su Colaboración de Reducción de Emisiones de Diesel por (DEREC, sus siglas en inglés). El combustible de sulfuro “ultra bajo” también se requiere para la actualización de la tecnología.

Problema: Los conductores de los camiones diésel usualmente dejan sus motores encendidos en sus áreas de descanso, aún cuando realizan paradas para dormir. De esta manera pueden activar el aire

acondicionado y diversos aparatos (tales como la refrigeración para la carga). Esto genera una cantidad importante de contaminación. Aunque los motores diésel a partir del modelo del año 2007 reducirán dramáticamente sus emisiones, el largo periodo de transición de la flota existente hace necesario que se aborde este tema ahora.

Estrategia: Los gobiernos de ambos lados de la frontera deben promover y proporcionar subsidios para proporcionar electricidad en las áreas de descanso de los camiones, en las estaciones de inspección en los puertos de entrada y en los puertos marítimos fronterizos. Ya está comercialmente disponible y en uso la tecnología que permite que los camiones se conecten a la red de electricidad en sus áreas de descanso; no obstante, se requiere de promoción y adopción acelerada. El uso de la electricidad en lugar de motores diésel no sólo reducirá la contaminación neta emitida sino que también le ahorrará dinero a las empresas camioneras en lo que respecta al desgaste de los motores. Estudios realizados han mostrado que las inversiones en la reducción de emisiones de diésel resultan en una alta relación de beneficios en la salud, costos, y por lo tanto los subsidios razonables se justifican.

Problema: El Tratado de Libre Comercio para América del Norte (TLCAN), ha tenido consecuencias significativas tales como un incremento en el intercambio comercial regional, incremento en el cruce fronterizo por sus residentes y el traslado de productos industriales y agrícolas provenientes de maquiladoras y ranchos en México hacia clientes en los Estados Unidos. Sin embargo, tanto las flotas de camiones de recorridos cortos como de largas distancias son atrasados por inspecciones largas y revisiones de seguridad efectuados en la frontera. Los programas destinados para abordar este problema (puertos de entrada “inteligentes” y “Fast Pass”/SENTRI/Líneas de Viajeros Frecuentes/”Sepas”) han sido paralizados.

Estrategia: El Departamento de Seguridad Nacional de los Estados Unidos debe de agilizar el tráfico en los puertos de entrada. Los Programas para llevar a cabo esto tienen beneficios económicos significativos. Cuando las líneas especiales son parte de un

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programa, deben incluir una preferencia por los vehículos más limpios incluyendo aquellos que han pasado por una inspección y mantenimiento minucioso.

Problema: Existen suficientes muy pocos programas de inspección y mantenimiento y los que existen no logran motivar completamente un mantenimiento de vehículos que asegure la operación de los mejores vehículos y por lo tanto los menos contaminantes.

Estrategia: Los gobiernos deben continuar todos los programas de inspección y mantenimiento en el lado estadounidense e implementar nuevos programas de inspección y manteniendo en el lado mexicano, enfocándose primero en los vehículos municipales. Los estándares deben adaptarse de modo inverso con la antigüedad del vehículo del lado mexicano para que de esta manera su acatamiento sea asequible y, por lo tanto, deseable por el público.

Problema: Los propietarios de vehículos estadounidenses con frecuencia venden sus vehículos usados (por lo tanto vehículos de mayor antigüedad, menos eficientes y en ocasiones sin inspección) a mexicanos. Asimismo, los vendedores de automóviles nuevos en México prohíben activamente la importación de vehículos con 10 años o menos de antigüedad, agravando así la bifurcación del mercado mexicano.

Estrategia: México debe impedir la importación de automóviles viejos e inadecuados adentro del país y requerir que las autoridades aduanales exijan una inspección del smog del estado que exporta y permitir la importación de automóviles más nuevos.

Problema: La planeación de una infraestructura para el transporte por lo general se quebranta en la frontera en donde una jurisdicción termina y otra comienza. Falta una coordinación suplementaria necesaria para asegurar el flujo continuo y eficiente de materiales, personas y productos en región fronteriza. A consecuencia, la frontera ha padecido de una larga marginalización de servicios, lo que es común en otras áreas. Por citar un ejemplo, el sistema ferroviario sólo existe en pocos lugares a lo largo de la frontera.

Estrategia: Los gobiernos y las personas interesadas del sector privado deben planear y proporcionar un transporte masivo a través de la frontera, incluyendo los viajeros del diario en grupos identificables, tales como estudiantes y compradores, que se dirigen hacia lugares específicos. Asimismo, todas las agencias fronterizas y de los puertos de entrada deben de coordinar los procesos de planeación ferroviario, terrestre, aérea, y marina a través de la frontera y con las diversas agencias aéreas, de transporte y de planeación.

Problema: Muchos productos provenientes del interior de México son descargados de los camiones de largas distancias y posteriormente cargados a flotas de camiones de corta distancia que, debido a sus funciones, no son tan bien mantenidas como los camiones de larga distancia.

Estrategia: Convertir y actualizar la flota para observar estándares modernos. Una ley de California recientemente aprobada (AB 1009) podría servir como modelo para implementar esta estrategia.

Escenario II: Fuentes de Energía Renovable y de Uso Eficiente

Problema: Muchas instalaciones en la zona fronteriza utilizan la energía en maneras que son técnicamente y económicamente ineficientes. Mejoras redituables en costo y eficacia podrían ahorrar cantidades significativas de electricidad y combustible y de ese modo reducir la contaminación del aire. Las ineficiencias existen en los procesos industriales, el calentamiento y enfriamiento de espacios y en varios aparatos y tecnologías (tales como bombas, ventiladores y motores).

Estrategia: Se recomienda una estrategia que consiste en dos partes. Primero, el gobierno debe exhortar a los administradores públicos y privados a que adopten prácticas agresivas de un “Sistemas de Gestión Ambiental”, incluyendo auditorias que identifiquen oportunidades para mejoras redituables en cuanto a la eficiencia. El apoyo del gobierno puede ser en forma de incentivos reglamentarios, talleres y asistencia técnica, y estos dos últimos enfoques pudieran

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ser transfronterizos. La Comisión de Calidad Ambiental de Texas, por ejemplo, debe revivir su programa impresionante financiado por la EPA sobre asistencia técnica a maquiladoras en estados vecinos, y otros estados deberían de emular este ejemplo. Segundo, para tratar el problema de escala y financiamiento, las firmas interesadas del sector privado (incluyendo las compañías de servicios de energía) deben de amontonar en propuestas de préstamos bancarios un número de oportunidades que de otra manera serían independientes de sitios en varias compañías o proyectos específicos. Entre las fuentes de financiamiento podrían el BDAN, y los proyectos mexicanos adicionalmente usar créditos de carbono desarrollados para aprovecharse del Mecanismo de Desarrollo Limpio del Protocolo de Kyoto. Como una extensión a esta estrategia (especialmente en México), los gobiernos deben ser proactivos con nuevos proyectos. Por ejemplo, la Comisión Federal de Electricidad junto con la Comisión Nacional para el Ahorro de Energía, podría inspeccionar los grandes proyectos propuestos para viviendas de personas de bajos ingresos, para oportunidades de adoptar eficiencia de energía desde un principio.

Problema: La región fronteriza tiene muy buenas fuentes de energía solar, incluyendo bolsas de fuentes de energía eólica, y tiene numerosos rellenos sanitarios de residuos sólidos cuya producción a largo plazo de metano podría apoyar la generación de electricidad. En muchos de los casos, estos recursos están cerca de la red y aún así su potencial casi no se ha aprovechado. Uno de los retos es el costo marginal de la producción.

Estrategia: El Congreso de los Estados Unidos debe expandir varios años más los créditos tributarios a la producción para la generación de energía renovable para combustibles. En México, el gobierno y el sector privado deben cooperar en identificar y obtener fuentes de financiamiento para cubrir los costos marginales, tal como los créditos de carbono y el Fondo para el Medio Ambiente Mundial (GEF, por sus siglas en inglés) del Banco Mundial.

Problema: Los gobiernos mexicano y estadounidense han establecido fondos para subsidios en el BDAN para proyectos relacionados con el agua, aguas residuales y residuos sólidos en la región fronteriza

para poder complementar los fondos para préstamos BDAN. Sin embargo, no existen fondos similares disponibles en el BDAN para proyectos relacionados con la energía renovable, la eficiencia de energía u otros esfuerzos que reducirían la contaminación del aire.

Estrategia: Los gobiernos mexicano y estadounidense deben expandir la disponibilidad de fondos para subsidios del BDAN para incluir la energía renovable, la eficiencia de la energía y otros esfuerzos que podrían reducir la contaminación del aire.

Problema: Aunque en México se construyeran puertos e instalaciones de regasificación de GNL que hicieran disponible el combustible para uso local, existe muy poco sistema de distribución en las ciudades mexicanas

Estrategia: El gobierno mexicano debe requerir que los constructores de puertos de GNL construyan el sistema de distribución para el uso por los residentes locales.

Escenario III: Leyes del Mercado Involucradas

Problema: Los Estados Unidos no cuenta con mecanismos que permita el intercambio transfronterizo de fondos para combatir contaminantes, provea compensaciones, crédito por reducción de emisiones y para la mitigación (con la excepción de un limitado programa estatal desarrollado en Texas), aunque estos mecanismos pudieran proporcionar grandes ganancias para las inversiones de reducción de la contaminación.

Estrategia: Los legisladores federales y estatales de los Estados Unidos deben establecer tales incentivos para el mercado como parte de los Planes de Implementación Estatal de áreas fronterizas. Esto debe lograrse primero a través de la legislación estatal relativos a las áreas (similar a la ley de Texas que permitía el intercambio de contaminación entre El Paso-Ciudad Juárez), y posteriormente a través de enmiendas a la Ley de Aire Limpio. La legislación Mexicana ya permite tales intercambios a través de los Artículos I-III y III-XI de la Ley General del Equilibrio Ecológico y Protección

al Ambiente (conocida regularmente como LGEEPA, por sus siglas en español) así como en los Artículos III-IV y III-V del Reglamento Federal para el Aire.

Problema: El sistema comercial bancario no aborda adecuadamente las oportunidades significativas que existen por los proyectos relacionados con tecnologías de energía alternativa.

Estrategia: Los gobiernos y las fundaciones deben mejorar los esfuerzos existentes para proporcionar fondos rotatorios de préstamos, incluyendo micropréstamos, para inversiones con costos redituables que reducen la contaminación del aire, especialmente a través de tecnologías de energía. Esto debería de incluir un programa binacional de micropréstamos que proporcione préstamos para la electrificación de las paradas de los camiones de carga. Tal programa podría ser financiado por peajes en los cruces fronterizos, cobros por impactos ambientales (fondos provenientes del desarrollo), o impuestos por el transporte.

Escenario IV: Mejores Controles de las Fuentes del Área Natural/Agrícolas

Problema: Las quemas agrícolas crean contaminantes que no sólo afectan los hogares o comunidades vecinas, sino también la calidad del aire en otras cuencas de aire, incluyendo aquellas que se extienden en la frontera.

Estrategia: Suponiendo que no existan alternativas para las quemas agrícolas, las agencias reglamentarias deben limitar los riesgos a la salud y otras consecuencias negativas desarrollando sistemas de permisos que incluyan requisitos para las condiciones y de notificación. Por ejemplo, en los días que se prevén excesos de los estándares, se deberían imponer días de “hoy no se quema”.

Problema: Actualmente la COCEF revisa y certifica, y el BDAN proporciona préstamos para proyectos de pavimentación como una estrategia para reducir la contaminación del aire, pero las condiciones y requisitos carecen de rigor con respecto a los siguientes factores importantes:

- Planear la pavimentación de las mejores calles (en ocasiones basados en las calles que los residentes o dueños de negocios están dispuestos a pagar)
- Conocer la cantidad de polvo que se evita por la resuspensión
- Evaluar las consecuencias a la salud y de los proyectos previos y posteriores
- Dar seguimiento con programas de limpieza de las calles para mantener niveles reducidos de polvo

Estrategia: Conforme se desarrollan propuestas para la pavimentación de calles, la COCEF debería proporcionar una selección basada en criterios y orientación técnica relacionada al conteo del tráfico, la calidad del aire y encuestas sobre la salud antes y después de los proyectos. Asimismo, la COCEF debe limpiar o regar las calles como actividad de seguimiento requerida. Los programas nuevos de transporte deberían ser financiados por peajes.

Escenario V: Mejor Recopilación de los Datos y Enlace Comunitario

Problema: Las agencias gubernamentales que recaban y/o analizan datos de la calidad del aire o de los impactos a la salud no están facilitando la disponibilidad de esa información para la educación del público y uso de la comunidad. Un tema relacionado a los datos en diversas partes de la región fronteriza es que los datos en tiempo real no está lo suficientemente disponibles o proporcionados mediante una interfaz inadecuada. Los investigadores por lo general están desconcentrados por la falta de universalidad y seguridad en la calidad.

Estrategia: Las agencias gubernamentales que tienen datos de la calidad del aire deben dar mayor consideración a las necesidades del público y de grupos de personas interesadas. Se recomiendan diversos enfoques. El primer paso debería ser el desarrollo y la estandarización de un índice de la calidad del aire a lo largo de ambos lados de la frontera para que todos compartan el mismo idioma al discutir las condiciones de la calidad del aire. De igual manera existe una clara necesidad de una campaña enfocada para educar a los políticos, profesionales de la salud y autoridades

educativas sobre los peligros de la contaminación del aire para que puedan comunicar tales riesgos a la salud a sus constituyentes. Diversas entidades del Programa 2012—el Grupo de Trabajo de Salud Ambiental, el Equipo de Trabajo de Indicadores Fronterizos y el Equipo de Trabajo de Comunicaciones—podrían ser particularmente eficaces en abordar este problema.

Problema: Las agencias gubernamentales que recaban y/o analizan datos de la calidad del aire o de los impactos a la salud no hacen disponible esa información de una manera óptimamente útil para su análisis. Los investigadores afrontan diversos retos: el acceso es difícil; el formato o presentación de los datos crudos no es clara y es inconsistente; la información por lo general no son presentados de una manera bilingüe; los datos respecto al porqué y cómo ciertos datos fueron recabados no existe o no se presenta con los datos correspondientes; y la información por lo general no está disponible.

Estrategia: Para asegurar que los datos sean tanto disponibles como óptimamente útiles, es necesaria la creación de un comité binacional que proponga a los dos gobiernos federales y estados, qué datos son necesarios y en qué formato serían más útiles.

PRIORIDADES ENTRE LOS ESCENARIOS DE ACCIONES EN EL ÁMBITO FEDERAL A PLAZOS INMEDIATOS

Muchas de las recomendaciones mencionadas anteriormente no pueden ser implementadas sin la participación activa de los gobiernos federales de México y de los Estados Unidos. Por lo menos cuatro acciones deberían de ser implementadas a corto plazo:

- México y los Estados Unidos deberían exhortar el desarrollo de tecnologías de energía nuevas renovables y basadas en la conservación en las discusiones regionales y por toda la frontera sobre la calidad del la aire llevadas a cabo y bajo el Programa Frontera 2012

- Conocimiento de los temas legítimos de soberanía, México y los Estados Unidos junto con los diez estados fronterizos, deben encontrar maneras de crear soluciones para la gestión de cuencas de aire transfronteriza
- México y los Estados Unidos deben designar oficialmente cuencas de aire binacionales comunes basados en la topografía, meteorología y en la salud
- México y los Estados Unidos deben proporcionar financiamiento de subsidios para un Fideicomiso Binacional para el Aire Limpio que puede sufragar los costos de una transición a las tecnologías que resulten en menos contaminación del aire

EL INCREMENTO DE LOS ESFUERZOS UNILATERALES Y COLABORATIVOS PUEDE LLEVAR AL ÉXITO

El mejoramiento eficaz de la calidad del aire en la frontera es un problema cada vez más complejo y como tal requiere de acciones por parte de diversas entidades gubernamentales. Algunas de las recomendaciones del VII Instituto Fronterizo surgieron sólo la acción unilateral a través de un organismo de un lado de la frontera; otras requieren acuerdos binacionales.

Durante el VII Instituto Fronterizo, Allen Olson, ex gobernador del estado de Dakota del Norte y miembro de la Comisión Conjunta Internacional entre los Estados Unidos y Canadá (IJC, por sus siglas en inglés), explicó que la IJC tenía 80 años de experiencia abordando temas transfronterizos cuando decidió afrontar el tema de la calidad del aire. La infraestructura social estaba madura. Quince años después de las discusiones iniciales, el Acuerdo de la Calidad del Aire (AQA, por sus siglas en inglés) entre los Estados Unidos y Canadá se firmó en 1991.

De igual manera, los Estados Unidos y México tienen la experiencia de desarrollar acuerdos binacionales en el área del agua desde 1889. Adicionalmente, tienen experiencias recientes en los últimos diez años con el incremento de los unilaterales y colaborativos para mejorar la calidad del aire. Estos esfuerzos, tanto unilaterales binacionales, han tenido resultados benéficos en

subregiones selectas. Estas experiencias proporcionan una base para proseguir con esfuerzos tales como las recomendaciones del VII Instituto Fronterizo. El Programa Frontera 2012 puede desempeñar una función muy importante al proporcionar los mecanismos y el liderazgo para implementar esfuerzos para mejorar la calidad del aire.

Aunque la relación México-Estados Unidos carece de ciertos elementos que pudieron haber facilitado las interacciones entre los Estados Unidos y Canadá—niveles similares de desarrollo económico y una historia cultural y legal similar—ciudadanos, numerosos políticos, educadores y profesionales de la calidad del aire y salud ambiental reconocen que los problemas de la calidad del aire en diversas partes de la región fronteriza México-Estados Unidos son serios y requieren de una acción colaborativa. Mayores esfuerzos, combinados con un progreso hacia un acuerdo binacional de la calidad aire, son esenciales para asegurar un medio ambiente limpio y un futuro económico positivo.

Muchas de las recomendaciones establecidas en este documento requieren sólo de una acción unilateral, y la mayoría de ellas tienen una historia que es anterior al del VII Instituto Fronterizo. Durante la conferencia, por ejemplo, Sergio Sánchez, Director General para la Gestión de la Calidad del Aire para SEMARNAT, reportó que México manifestó recientemente su intención de proporcionar combustible de sulfuro “ultra bajo” para este año para los vehículos de gasolina, y en el año 2008 para los vehículos de diésel. Parte del incentivo para que PEMEX convierta sus refinerías—una tarea de varios billones de dólares— es su deseo de poder vender combustible a camiones con licencia estadounidense que realizan largos trayectos hacia México. Sin embargo, a PEMEX se le gravan tributos muy fuertes por parte del gobierno federal y tiene pocos recursos disponibles para invertir.

La Figura 3 delinea un proceso posible para lograr un Acuerdo sobre la Calidad del Aire (AQM, siglas en inglés) entre México y los Estados. La figura 3 comienza con el Acuerdo de La Paz y sus programas de implementación: el Plan Ambiental Fronterizo Integrado, (IBEP, por sus siglas en inglés), Frontera XXI a finales de la década de 1990 y el actual Frontera 2012. La iteración actual

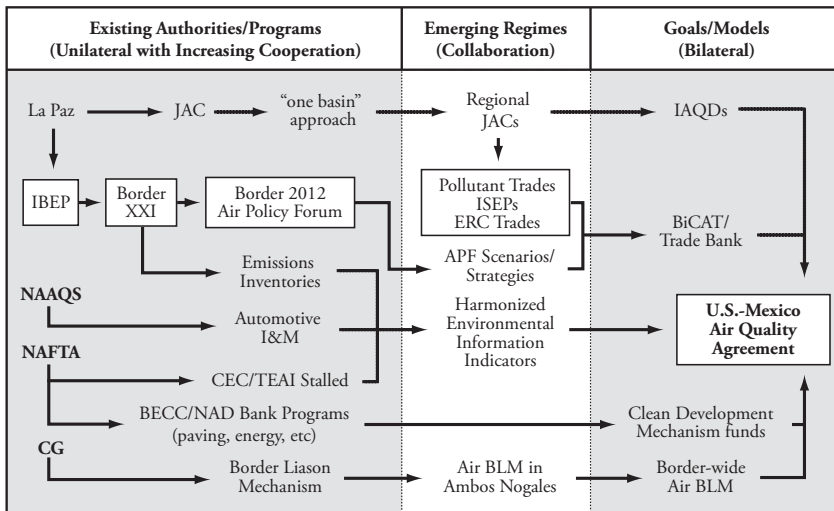
Binational Air Quality Management

tiene un Foro de Políticas del Aire, un mecanismo para coordinar acciones entre los niveles de gobierno así como con las autoridades de la salud.

El Acuerdo de La Paz también hizo posible al JAC, el cual ha fomentado la filosofía de una cuenca que permite el intercambio selecto de contaminantes.

Existen también comités consultivos interjurisdiccionales similares, con el poder facilitador del Mecanismo de Enlace Fronterizo (MEF), de los Cónsules Generales, como el de Ambos Nogales, y sin la autoridad facilitadora, como se observa en Mexicali-Valle Imperial. Los MEF permiten que los gobiernos locales puedan negociar y llegar a un acuerdo sobre una serie de soluciones que posteriormente son aprobadas por los respectivos gobiernos federales en vez de tener que seguir cada paso de una negociación hasta llegar a nivel federal y a través del mismo. Ambas subregiones ya están incluidas en los Grupos de Trabajo del Aire de Frontera 2012 y están avanzando lento pero seguro en dirección de convertirse distritos internacionales de la calidad del aire, (IAQDs,

Figura 3. A Path to a U.S.-Mexican Air Quality Agreement



Source: Author

por sus siglas en inglés) aunque eso actualmente no está autorizado por ningún reglamento actual estatal, federal o local. Un proyecto propuesto en California establecería un organismo similar al JAC con su estado mexicano vecino y también avanzaría para obtener el estatus de IAQD.

Las instituciones del TLCAN han demorado en abordar los temas de la calidad del aire. Mientras que la Comisión para la Cooperación Ambiental, (CCA, por sus siglas en inglés), se encuentra entretenida con las Evaluaciones de los Impactos Ambientales Transfronterizos, (TEIAs, por sus siglas en inglés), la COCEF ha certificado y el BDAN ha financiado un número de proyectos de aire y de energía. Un fondo subsidiario para proyectos del aire (o un banco de intercambio de emisiones) para complementar al Fondo de Infraestructura Ambiental Fronteriza, (BEIF, por sus siglas en inglés) del agua y de las aguas residuales podría ser auspiciado por el BDAN.

El Mecanismo de Desarrollo Limpio (MDL) de Kyoto, las Naciones Unidas, el Fondo para el Medio Ambiente (GEF, siglas en inglés) y los programas de la EPA de “Metano al Mercado” ofrecen incentivos y posibles fuentes de financiamiento para proyectos relacionaos con mejorar la calidad del aire. Al mismo tiempo, se encuentran en desarrollo esfuerzos unilaterales pero coordinados para caracterizar las fuentes de contaminación del aire y la calidad del aire ambiente a lo largo de la frontera. El sector privado también está desarrollando su labor. Se están mejorando los vehículos y se están construyendo las plantas de energía con tecnologías más avanzadas que reducen las emisiones.

Se ha logrado un progreso significativo hasta la fecha para abordar los temas de la calidad del aire de la región fronteriza México-Estados Unidos, incluyendo la coordinación de actividades tecnológicas tales como el monitoreo, modelado y la disponibilidad de datos. Existen por lo menos tres pasos importantes:

- Institucionalizar un grupo formal binacional de estudio científico del aire
- Notificar y consultar a través de la frontera sobre nuevas emisiones de aire significativas y sobre emisiones continuas y molestas (quemadas agrícolas) así como sobre sus impactos

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- Desarrollar y compartir informes individuales del status y progreso de la nación

La protección de la calidad del aire en la región fronteriza México-Estados Unidos es demasiado importante como para retrasar la acción en cuanto a estas recomendaciones que se generaron en el VIII Instituto Fronterizo. Si las acciones actuales se mantienen es probable que la calidad del aire se degrade. Mientras que se ha llevado a cabo un progreso significativo la calidad del aire debe ser incluida en la agenda de todos los esfuerzos e iniciativas binacionales, especialmente aquellas que abordan los temas de la energía y del agua. Mientras más pronto se plantee y se trate en los niveles más altos el tema de la calidad del aire y sus impactos de la salud ambiental relacionados, será más probable mejorar la calidad del aire y la salud humana, y evadir tensiones internacionales innecesarias, evitando conflictos sobre este problema que finalmente, de hecho, tiene solución.

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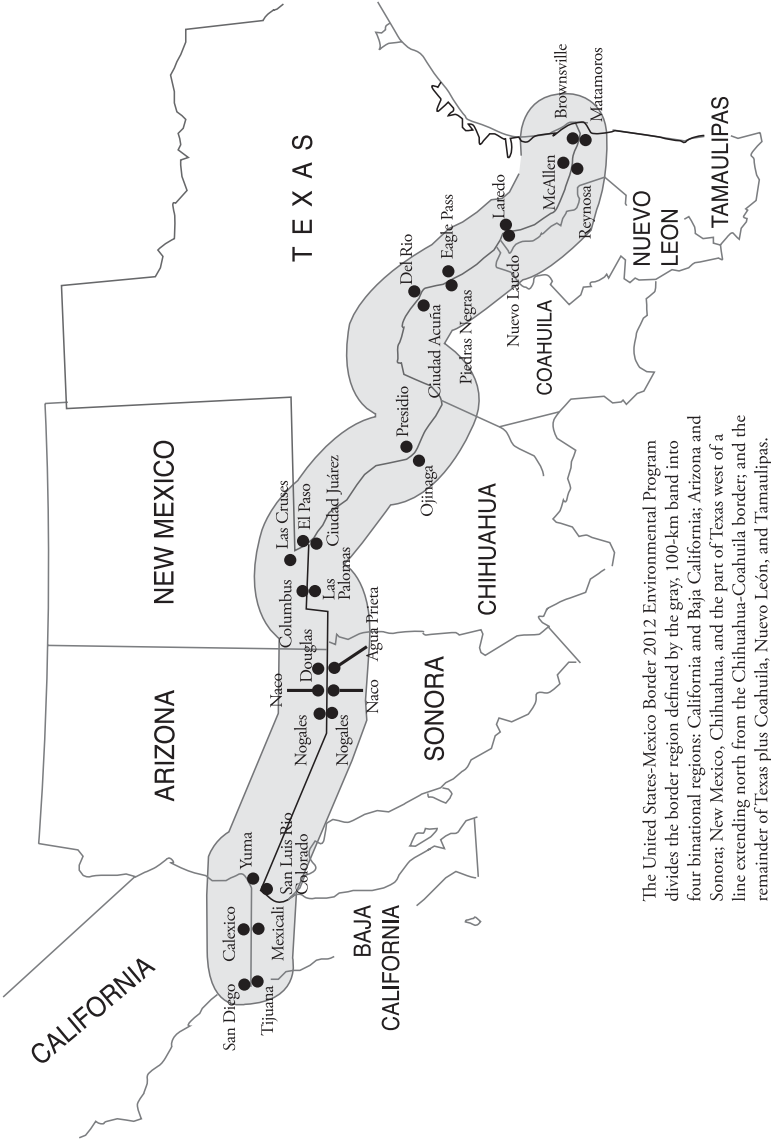
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Figure A. U.S.-Mexican Border Region and Sister Cities



The United States-Mexico Border 2012 Environmental Program divides the border region defined by the gray, 100-km band into four binational regions: California and Baja California; Arizona and Sonora; New Mexico, Chihuahua, and the part of Texas west of a line extending north from the Chihuahua-Coahuila border; and the remainder of Texas plus Coahuila, Nuevo León, and Tamaulipas.

Binational Air Quality Management

Table A. Ambient Air Quality Standards in the United States and Mexico

Pollutant	U.S. Standard		Mexican Standard	
	Time Period for Calculation	Concentration Level	Time Period for Calculation	Concentration Level
Ozone (O ₃)	1-hour average	0.12 ppm	1-hour average	0.11 ppm
	8-hour average	0.08 ppm		
Sulfur Dioxide (SO ₂)	24-hour average	0.14 ppm	24-hour average	0.13 ppm
	Annual arithmetic mean	0.03 ppm	Arithmetic mean	0.03 ppm
Nitrogen Dioxide (NO ₂)	Annual arithmetic mean	0.053 ppm	1-hour average	0.21 ppm
Carbon Monoxide (CO)	8-hour average	9 ppm	8-hour average	11 ppm
	1-hour average	35 ppm		
Total Suspended Particulates (TSP)	no standard		24-hour average	210 µg/m ³
PM ₁₀	24-hour average	150 µg/m ³	24-hour average	120 µg/m ³
	Annual arithmetic mean	50 µg/m ³	Annual arithmetic mean	50 µg/m ³
PM _{2.5}	24-hour average	65 µg/m ³	24-hour average	65 µg/m ³
	Annual arithmetic mean	15 µg/m ³	Annual arithmetic mean	15 µg/m ³
Lead		1.5 µg/m ³	3-month arithmetic mean	1.5 µg/m ³

Notes: PPM is parts per million; µg/m³ is micrograms per cubic meter

Sources: U.S. Environmental Protection Agency and the Secretaría de Medio Ambiente

Binational Air Quality Management

Table B. Determination of Attainment in the United States (criteria for implementing the standards in Table A)

Pollutant	Time Period for Calculation	Calculation to Determine Nonattainment ¹
Ozone (O ₃)	1-hour average	Concentration levels, averaged over one hour, equal or exceed 125 parts per billion (ppb) more than three times during a consecutive three-year period.
	8-hour average	Average of yearly fourth-highest 8-hour ozone levels over three years equals or exceeds 85 ppb.
Sulfur Dioxide (SO ₂)	24-hour average	Concentration levels, averaged over 24 hours, exceed 0.14 parts per million (ppm) more than once in a calendar year.
	Annual arithmetic mean	Annual arithmetic mean of concentrations exceeds 0.03 ppm.
Carbon Monoxide (CO)	1-hour average	Concentration levels, averaged over one hour, equal or exceed 35.5 ppm more than once in a calendar year.
	8-hour average	Concentration levels, averaged over 8 hours, equal or exceed 9.5 ppm more than once in a calendar year.
PM ₁₀	24-hour average	Concentration levels, averaged over 24 hours, exceed 150 µg/m ³ more than once in a calendar year.
	Annual arithmetic mean	A three-year average of weighted mean concentrations exceeds 50 µg/m ³ .
PM _{2.5}	24-hour average	A 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor exceeds 65 µg/m ³ .
	Annual arithmetic mean	A 3-year average of the annual arithmetic mean PM _{2.5} concentrations from single or multiple community-oriented monitors exceeds 15 µg/m ³ .

¹ Each of these calculations is performed on each monitor in an area, and a violation at any one monitor determines nonattainment for the area, unless otherwise indicated.

Source: U.S. Environmental Protection Agency

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Issues Related to Air Quality and Health in the California-Baja California Border Region

*Margarito Quintero Núñez, Marco Antonio Reyna,
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ABSTRACT

A rapidly increasing population living in a diverse and dynamic region, stark differences in air quality, economic disparity, lack of harmonized data, insufficient resources or technology, and different perspectives on the quality of the environment—these are just a few of the challenges found in the California-Baja California border region. This chapter discusses a number of these challenges and proposes recommendations and solutions.

Air quality data indicate that the cities of San Diego, California, and Tijuana, Baja California, are either in attainment or close to attainment with respect to their respective national ambient standards for all regulated pollutants, despite some historical problems. In comparison, Imperial County, California, and the *municipio* of Mexicali, Baja California, experience high levels of particulate matter measuring 10 microns or less (PM₁₀) and certain toxic air

contaminants. They have seen improvements in ozone and carbon monoxide. Air pollution has health effects. Although the associations are not completely clear, a number of studies point to increased health impacts with additional contamination.

Despite the negative data in the Imperial-Mexicali area and pessimistic projections for selected pollutants, people do enjoy living in the region. People have choices about where they live and the residents of Calexico, California, and Mexicali, even though they notice the air quality is bad, place significant value on other positive local conditions. This is even more so in Calexico—comparatively, local conditions people notice every day are better in Calexico than Mexicali. This plays a significant role in the development of individuals' perspectives in the region. A corollary of that perception is that because environmental issues are not at the top of residents' concerns, it is difficult to convince governmental entities to focus the appropriate level of resources on the region's air issues.

Researchers within and outside the area have been conducting scientific and social studies to understand the complexities of the region. More such research is merited, and this chapter makes several additional recommendations, including the need for the harmonization of data, designation of binational airsheds, harmonization of vehicle inspection and maintenance programs, and coordination of policies regarding energy production. Also, to improve air quality in the California-Baja California region, resources are needed to build technological infrastructure as well as human capacity and understanding, and for programs in pollution reduction.

The principal sources of pollution in the California-Baja California border region are industry (carbon monoxide in Mexicali; sulfur dioxide in Tijuana); energy (fast food operations in Tijuana and geothermal and fossil fuel-fired power plants in Mexicali); and transportation (vehicles constitute the principal source of emissions in this region). As well, the largest contributors to particulate matter levels are unpaved roads, wind erosion of soils, burning of agricultural waste and trash, and open air grills.

Issues Related to Air Quality and Health in the California-Baja California Border Region

Imperial County and Mexicali provide a good case study of border problems with air quality. These two communities—in violation of their respective national standards for particulate matter and ozone—have extremely high levels of respiratory problems among children.

The construction of natural gas-fired power plants in the Mexicali area exclusively to serve the California energy market has occurred and is likely to continue. These power plants are among the largest single sources of air pollution in the California-Baja California border region, and the power plants in Rosarito (natural gas) and Cerro Prieto (geothermal) are also noteworthy. In the case of the latter, the emission of hydrogen sulfide (and even carbon dioxide) is significant.

Aspectos Relacionados con la Calidad del Aire y la Salud en la Región Fronteriza de Baja California- California

Margarito Quintero Núñez, Marco Antonio Reyna,

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RESUMEN

Una población en rápido crecimiento que habita una región diversa y dinámica; diferencias austeras en la calidad del aire; disparidades económicas; falta de información homogeneizada; insuficiencia de recursos o tecnología y diferentes perspectivas sobre la calidad del medio ambiente —son sólo algunos de los retos que caracterizan a la

región fronteriza de Baja California-California—. En este apartado se discuten varios de estos retos y se proponen algunas recomendaciones y soluciones.

La información de la calidad del aire indica que las ciudades de Tijuana, Baja California y San Diego, California están en cumplimiento o casi en cumplimiento de sus respectivas normas ambientales nacionales de todos los contaminantes de regulados a pesar de algunos problemas históricos. En comparación, el Condado de Imperial, California, y el municipio de Mexicali, Baja California, padecen de altos niveles de materia particulada que mide 10 micrones o menos (PM_{10}) y de ciertos contaminantes tóxicos del aire. Se han observado mejoras en lo que respecta al ozono y al monóxido de carbono. Existen efectos a la salud debidos a la contaminación del aire. Aunque las correlaciones aún no son completamente claras, un número de estudios muestran mayores impactos a la salud debido a la contaminación del aire.

No obstante los datos negativos en el área de Mexicali e Imperial y las proyecciones pesimistas de contaminantes selectos, a los habitantes les gusta vivir en la región. La gente tiene opciones de donde vivir y aunque los residentes de Mexicali, Baja California y Caléxico, California, notan que la calidad del aire es mala, le dan un valor importante a otras condiciones locales positivas. Esto es más evidente en Caléxico: comparativamente, las condiciones que la gente nota todos los días son mejor en Caléxico que en Mexicali. Esto tiene una influencia importante en el desarrollo de las perspectivas de las personas en la región. Un corolario de esa percepción es que debido a que los temas ambientales no se encuentran al principio de la lista de preocupaciones de los residentes, es difícil lograr que las entidades gubernamentales enfoquen el nivel apropiado de recursos en los temas del aire de la región.

Los investigadores dentro y fuera del área han estado realizando estudios científicos y sociales para entender las complejidades de la región. Se requiere más trabajo de tales investigaciones y este capítulo hace varias otras recomendaciones que incluyen la necesidad de homogeneizar la información, la designación de cuencas binacionales de aire, la armonización de los programas de inspección y mantenimiento de vehículos y una coordinación de políticas referentes a la producción de energía. Adicionalmente, para

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mejorar la calidad del aire en la región de Baja California-California, se necesitan recursos para construir una infraestructura tecnológica, desarrollar capacidad humana y entendimiento y para programas relacionados a la reducción de la contaminación.

Las principales fuentes de contaminación en la región fronteriza Baja California-California son: la industria (monóxido de carbono en Mexicali, CO) (dióxido de azufre, SO₂ en Tijuana). La energía (las operaciones de comida rápida en Tijuana y las plantas de generación eléctrica geo-térmicas y de activación con combustible fósil en Mexicali) y el transporte de los vehículos constituye la fuente principal de emisiones en esta región. Asimismo, las fuentes mayores de contribución a los niveles de materia particulada, son las calles sin pavimentación, y generación por la erosión eólica de los suelos, la quema de residuos agrícolas y de basura y asaderos al aire libre.

El Condado Imperial y Mexicali proveen un buen estudio de caso de los problemas fronterizos con la calidad del aire. Ambas comunidades—las cuales están en violación de sus respectivas normas nacionales para la materia particulada y el ozono—tienen niveles sumamente elevados de problemas respiratorios en los niños.

Se ha construido en el área de Mexicali plantas de energía que usan gas natural y que son exclusivamente para atender al mercado de energía de California; es probable que esta tendencia continúe. Estas plantas se encuentran entre las fuentes individuales más grandes de contaminación del aire en la región fronteriza de Baja California-California. Las plantas de energía de Rosarito (gas natural) y de Cerro Prieto (geotermal) también tienen que ser mencionadas. En el caso de la planta de Cerro Prieto, la emisión de sulfuro de hidrógeno (e incluso de dióxido de carbono) es significativa.

INTRODUCTION

The California-Baja California border extends 220 kilometers. Two counties (Imperial in the east and San Diego in the west) are on the California side and three *municipios* (from east to west Mexicali,

Tecate, and Tijuana) are on the Baja side. It is a complex and diverse region offering its residents beaches, mountains, and a desert (much of which is below sea level).

The western part of the region is heavily populated on both the California and Baja California sides, with a population of more than 4 million in 2000. Population growth rates have slowed in San Diego, likely because of housing costs, but have been very high in Tijuana. The eastern portion of the region—the Imperial and Mexicali Valleys—is not as populated, with 1 million people in 2000, but is growing at a fairly high rate (Sweedler 2003). Table 1 shows the growth in the principal portions of the region during the 1990s.

The differences in climate, population, and economic activities contribute to dynamics within the two sub-regions that are reflected in very different air quality issues. This chapter reviews which air pollutants present problems in the sister cities of San Diego-Tijuana and Imperial-Mexicali, related health ramifications, residents' perceptions of these issues in each sub-region, and a few successes and failures that have occurred as a result of efforts to address the challenges. It is not meant to be a thorough analysis, but it does provide an overview of recent data for the region, as well as recommendations.

On the U.S. side, the U.S. Environmental Protection Agency (EPA) has delegated most responsibilities for air quality management to the states. In turn, California has established regional air pollution control districts. These districts are responsible for moni-

Table 1. Population in the California-Baja California Border Region

County/Municipio	1990	2000	Percent Change
San Diego	2,498,016	2,813,833	12.6
Tijuana	747,381	1,212,232	62.2
Imperial	109,303	142,361	30.2
Mexicali	601,938	764,902	27.1

Source: U.S. Census Bureau 1990 and 2000, and Instituto Nacional de Estadísticas, Geografía e Informática

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toring and assessing air quality and for developing and implementing policies and programs to reduce air pollution pursuant to the federal Clean Air Act and the California Clean Air Act. The border region has two such districts—the San Diego County Air Pollution Control District (APCD) and the Imperial County APCD.

In Mexico, the federal Instituto Nacional de Ecología (in English National Ecology Institute), a unit within the Secretaría de Medio Ambiente y Recursos Naturales (in English Secretariat for Environment and Natural Resources) (SEMARNAT) oversees all these functions but delegates selected responsibilities to the states and *municipios*.

STANDARDS AND MONITORING

The two countries have established similar health-based ambient air quality standards for carbon monoxide, sulfur dioxide (SO₂), ozone, nitrogen dioxide, particulate matter measuring 10 microns or less in diameter (PM₁₀), PM measuring 2.5 microns or less in diameter (PM_{2.5}), and lead. Mexico also has standards for a broader definition of particulate matter called, in English, total suspended particulates. Table A in the front section of this monograph compares the Mexican and U.S. standards. The principal differences are that Mexico does not yet have an eight-hour ozone standard and the United States no longer has standards for total suspended particulates.

The San Diego APCD began monitoring air quality in the mid-1950s and expanded the monitoring significantly in the 1970s after the federal Clean Air Act was passed. Currently the district measures ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter (PM₁₀ and PM_{2.5}), lead, and selected toxics. In Tijuana, Mexican authorities began monitoring in 1990 but started using new monitoring equipment in 1997 and currently measure ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter (PM₁₀), lead, and toxics.

The Imperial County APCD has been monitoring air quality since 1990 and currently measures ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter (PM₁₀ and PM_{2.5}), lead, and toxics. In Mexicali, Mexican authorities began monitoring

in 1990 but (as in Tijuana) started using new monitoring equipment in 1997. They currently measure ozone, sulfur dioxide, nitrogen dioxide, particulate matter (PM₁₀ and PM_{2.5}, the latter only at a monitor at the Universidad Autónoma de Baja California), lead, and toxics. Table 2 shows the number of sites at which the relevant jurisdictions measure the pollutants of principal concern, plus toxics.

ASSESSMENT OF THE DATA—WHAT AND WHERE ARE THE AIR QUALITY PROBLEMS?

In addition to the U.S. standards listed in Table A, EPA has issued criteria for determining when the pattern of concentrations of a specific pollutant in a particular geographical area over a one- to three-year period (the number of times the standard is exceeded) constitutes a violation. See Table B (also near the front of this volume) for a list of these criteria. When a violation occurs, the area is designated nonattainment for that pollutant and various requirements aimed at reducing the offending pollutant or pollutants take effect.

Mexico currently does not have a similar system for official designation of areas with problems, but the EPA methodology can be applied unofficially to determine whether the concentrations of a pollutant in a Mexican municipio over a period of time would place the community in nonattainment. Data from monitors in some

Table 2. Air Quality Monitoring Stations in the California-Baja California Border Region

County/Municipio	Number of Monitoring Stations			
	Ozone	Carbon Monoxide	PM ₁₀	Toxics
San Diego	9	5	6	2
Imperial	6	3	6	1
Tijuana	3	3	5	0
Rosarito	1	1	1	1
Tecate	1	1	1	0
Mexicali	3	3	5	1

Source: California Air Resources Board

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Mexican *municipios*, when combined with data available about emissions from specific local sources, provide sufficient information to make such determinations.

Table 3 lists the California border cities in violation, or nonattainment, of U.S. ambient air quality standards and the border *municipios* in Baja California where available data indicate potential nonattainment.

The California Air Resources Board (CARB) recently analyzed the air quality data for several years (1997 through 2003) for California and Baja California border cities. The pollutants examined included ozone, carbon monoxide, and PM. The following subsections provide a summary of the findings (CARB 2005).

Ozone Trends

Because the U.S. eight-hour ozone standard was not in effect until after the study period, and because Mexico does not have an eight-hour standard, the CARB study looked only at the one-hour standard. Table 4 shows the number of days on which one or more monitors in the two California counties and two Baja California *municipios* registered exceedances of the one-hour standard annually from 1997 to 2003. To meet the EPA threshold for attainment, no single monitor can register more than three exceedances in any three-year period.

**Table 3. Attainment Designations in California
Border Counties, and Equivalent Unofficial
Determinations for Baja California *Municipios***

County/ Municipio	Pollutant			
	Ozone		CO	PM ₁₀
	One-hour	Eight-hour		
San Diego	Standards met	In violation	Standards met	Standards met
Tijuana	Standards met	In violation	Standards met	In violation
Imperial	In violation	In violation	In violation	In violation
Mexicali	In violation	In violation	In violation	In violation

Source: EPA 2001

Table 4. Days Exceeding the National One-hour Ozone Standard

County/ Municipio	Numbers of Days on Which the Standard was Exceeded ¹							
	1997	1998	1999	2000	2001	2002	2003	2004
Tijuana	3	0	0	1	0	0	0	1
San Diego	1	9	0	0	2	0	1	1
Mexicali	15	14	18	7	7	5	5	1
Imperial	10	5	24	5	10	3	3	0

¹ The number of days on which at least one monitor in the county or municipio measured a 1-hour average concentration greater than or equal to 125 ppm, which is the U.S. criterion.

Source: California Air Resources Board 2005

In the seven-year period covered by the analysis, 1998 was clearly a bad year for San Diego, with eight days of exceedances, but three of the other years saw no exceedances and the remaining three years saw two or three exceedances each. It is conceivable, therefore, that a continuing program of pollutant reductions could bring San Diego into attainment in relatively few years. Tijuana, meanwhile, exceeded the one-hour standard in 1997 on three different days, but in five of the six subsequent years registered no exceedances (insufficient data in 2000 precludes any statements about exceedances in that year). Using U.S. criteria, then, Tijuana would have been in attainment under the one-hour standard.

Monitors in Imperial County and Mexicali, on the other hand, have registered multiple exceedances of the U.S. one-hour ozone standard in each year shown. Looking on the bright side, the number of days of exceedances in Imperial County in 2002 and 2003 declined from previous years. The numbers of exceedances in Mexicali also declined, but in three of the last three years were higher than those in Imperial.

Carbon Monoxide Trends

Table 5 shows San Diego did not exceed the U.S. eight-hour standard for carbon monoxide during the selected time period. Tijuana has approximately three days per year that exceed the standard. Carbon monoxide levels decreased in Imperial County from 13 days of exceedances in 1999 to no days of exceedances in 2003. Mexicali, on the other hand, has had many days with exceedances each year since 1997.

PM₁₀ Trends

As with the eight-hour carbon monoxide standard, San Diego did not exceed the national 24-hour standard for PM₁₀ from 1997 to 2003 (Table 6). Tijuana averages three days per year with average concentrations exceeding the U.S. national standard (in the United States, an area is in nonattainment if a three-year average of the 99th percentile of concentration levels, based on 24-hour averages, exceeds the standard).

Calexico's levels of PM₁₀ average approximately four exceedances per year. Monitors in Mexicali registered a peak number of exceedance days—nearly 50—in 2000 and since then have averaged well over 30 days of exceedance per year.

Table 5. Days Exceeding the National Eight-hour
Carbon Monoxide Standard

County/ Municipio	Numbers of Days on Which the Standard was Exceeded ¹							
	1997	1998	1999	2000	2001	2002	2003	2004
Tijuana	2	1	2	3	1	1	0	0
San Diego	59	82	85	60	59	60	36	23
Mexicali	0	0	0	0	0	0	1	0
Imperial	10	8	11	6	6	3	0	1

¹ The number of days on which at least one monitor in the county or municipio measured a 8-hour average concentration greater than or equal to 9.5 ppm, which is the U.S. criterion.

Source: California Air Resources Board 2005

Table 6. Days Exceeding the National 24-hour
PM₁₀ Standard

County/ Municipio	Numbers of Days on Which the Standard was Exceeded ¹							
	1997	1998	1999	2000	2001	2002	2003	2004
Mexicali	21	23	30	49	40	34	35	46
Tijuana	3	3	5	1	2	3	1	4
San Diego County	0	0	0	0	0	0	1	0
Imperial County	4	2	5	6	3	3	4	2

¹ The number of days on which the monitor with the largest number of exceedances in that county or municipio for that year measured a 24-hour average concentration greater than 150 µg/m³, which is the U.S criterion for attainment (see Table B).

Source: California Air Resources Board 2005

Summary of Air Quality in the California-Baja California Border

The cities of San Diego and Tijuana are either at attainment or close to attainment for the regulated pollutants. In comparison, Imperial County and the municipio of Mexicali have seen some improvements in ozone and carbon monoxide, but PM₁₀ and toxic air contaminant levels are still high in Mexicali.

POLLUTION SOURCES

Industry

The use of diverse fuels in the region and energy generation and consumption is a significant source of pollutants. In Tijuana in particular, fast food operations continue to increase with few environmental controls. These activities include taco, chicken, and hamburger stands located in both residential and industrial areas. There have been a number of studies pinpointing the amount of emissions from these food stands but they have yet to be incorporated into the national emissions inventories and diagnosis.

Electricity Generation

In Mexicali, the geothermal plants of Cerro Prieto are a source of carbon dioxide, hydrogen sulfide, and methane (Comisión Federal de Electricidad 2004). In addition, there are two new thermoelectric power plants in Mexicali that contribute additional carbon monoxide, nitrogen dioxide (NO_x), and PM₁₀ to the already degraded air quality in the region. Issues related to electricity generation and natural gas supply are prominent in public debate and are treated in more detail later in this chapter.

Transport

The consumption of fuels by vehicles constitutes the principal source of emissions in this region. Motor vehicles are primary sources of ozone precursors, carbon monoxide, and toxics. This source of emissions is a central issue because of population growth rates and increased vehicle use. Additional sources on the Mexican side include the large number of used vehicles (which are insufficiently maintained from an emissions perspective) and the significant use of pick-up trucks in the cross-border trade of goods. Another important factor in the transport sector is the idling that occurs in the long lines of cars, pick-up trucks, and diesel trucks at the binational ports of entry.

Area Sources

The categories of area sources contributing the most pollution, particularly PM, are unpaved roads and wind erosion of soils. This is especially true in Baja California's *municipios*, where there are many unpaved streets. Additional area sources of PM are the burning of agricultural waste and trash and open-air grills. Agricultural burning is part of the process of land preparation for new crops and is common in both the Mexicali and Imperial Valleys. Other important categories are the commercialization and distribution of fuels, such as emissions from gasoline service stations, the cleaning of surfaces in industry, and commercial and domestic use of solvents.

THE EFFECTS OF AIR POLLUTION ON HEALTH

The human body has to cope with many forms of air pollution, including those in the form of noxious gases (ozone, carbon monoxide, SO_2 , and NO_x) and PM. PM includes dust, soil, mold, pollen, smoke, soot, and ash. Some PM comprises minute droplets of liquid or solids called aerosols. Toxic and cancer-causing agents can attach to PM and be breathed into the lungs. PM can range in size from visible pieces of sand to particles so small that thousands of them could fit onto the period at the end of this sentence. Most PM_{10} is trapped in the nasal passages or upper lungs, where small hairs and mucus move them out of the body. Nonetheless, PM_{10} can be inhaled farther and slip past the body's defenses.

In a study published in 1999, Reyna and Álvarez found respiratory illnesses, hospital admissions, school absences, and premature deaths are more frequent during periods of increased PM pollution. These periods of increased PM levels can exacerbate or cause lung diseases like asthma, bronchitis, and emphysema.

Recent studies indicate the smallest particles can enter the deepest parts of the lungs and remain trapped there, causing even more serious health effects for many people. After a review of more than 3,000 research studies related to PM and ozone (summarized in Sheth and Giel 2000), EPA proposed new air quality standards to regulate the smaller PM- $\text{PM}_{2.5}$.

The lungs are very sensitive to air pollution. PM can damage the lungs by inflaming or destroying the lung tissue, damaging or destroying the protective hair lining in the airways, or inflaming lung tissue and restricting air passages. Breathing becomes difficult and symptoms like coughing, wheezing, and shortness of breath occur.

Scientists are concerned about PM's effects on morbidity and mortality in the exposed population. It is estimated that in the United States alone some 64,000 premature deaths are related to PM; these represent 6.5% of the total deaths by cardio-respiratory diseases (NRDC 1996). There are a number of important key studies that show the injurious effects PM_{10} and $\text{PM}_{2.5}$ produce on the health of human beings, not only in the cardiorespiratory system but also in the cardiovascular system (Nemmar 2002, Peters 2000,

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Task Force of the European Society of Cardiology 1996, and Tsuji 1996). Other studies (Peters 1997 and Brunekreef 2002) point out that the ultra-fine particles (those less than one micron in diameter) have more prejudicial effects due to their capacity to penetrate into the alveolus, which produces local inflammation that can cause changes in the cardiac rhythm and abnormalities in the blood coagulation.

A study conducted by the U.S. Health Effects Institute (HEI) in 90 U.S. cities provides evidence that with every increase of 10 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) in PM_{10} concentration, hospitalizations for cardiovascular diseases increase by 1% and cardiopulmonary illnesses increase by 2% (HEI No Date). Other meta-analysis studies suggest that the same increment of PM_{10} concentration (i.e., $10 \mu\text{g}/\text{m}^3$) is associated with a 2% increase in deaths due to respiratory problems, a 2.5% increase in hospitalizations for cardiopulmonary obstructive diseases, and a 3% increase in symptoms of asthma and upper respiratory tract infections (Pope 1999).

Like the majority of sister-city pairs in the U.S.-Mexican border region, Mexicali and Calexico form a zone with notable economic dynamism derived from industry, commerce, agriculture, and on a smaller scale, tourism. Despite the benefits of this dynamism and growth, however, the capacity of local governments to carry out programs related to public and environmental health, management of solid waste, environmental education, and other efforts to protect environmental quality has not increased proportionately to the challenges (Canales 1999).

SEMARNAT recently noted that Mexicali is the second-most contaminated Mexican city for PM_{10} , and that the concentrations of carbon monoxide and ozone in the municipio are also consistently above the national standards (Instituto Nacional de Ecología 1998). There is added concern in the Mexicali-Imperial binational population that the two new thermoelectric plants recently constructed in Mexicali (the Semptra and Intergen plants) will further aggravate air quality (Cornejo 2002a and Cornejo 2002b).

Serious health issues have been identified in the region, particularly respiratory system and heart illnesses, according to Instituto de Servicios de Salud Publica. English, et al. (1998) reported on a comparative study of San Diego and Imperial Counties that found

Imperial County has the highest rate of asthma hospitalizations in California for those younger than 14 years old. Additionally, Imperial registered an increase in asthma hospitalizations of 59% from 1983 to 1994, compared to 9% for San Diego. Secretaría de Salud reported that in 1991 in Mexicali for every 10,000 inhabitants under 14 years of age there were 5,740 cases of acute respiratory infection (ARI), and in 2000 that rate increased to 9,688—an increase of 69%.

Regionally, a number of preliminary studies have explored the relationship between air quality and respiratory health (Osornio 1991, Reyna Carranza 2003, Reyna Carranza 2004, Collins 2001, and Collins 2003). To further the understanding of the relationships between air contaminants and diseases due to respiratory disorders, Universidad Autónoma de Baja California has developed a Poisson model for each of the three main morbidity variables—asthma, pneumonia, and ARI—and is preparing a study for publication.

In this study, time series data for the respiratory diseases have been used as response variables. The weather time series (temperature, relative humidity, and quadratic effects of weather), seasonality components, population growth, and the exceedances (days on which air pollutants surpassed the air quality standards) were used as confounding variables. Ambient concentrations of ozone, PM_{10} , and carbon monoxide were included as predictor variables, first individually and then in the three paired combinations of those pollutants. Using Akaike's information criterion (AIC), variables were selected as significant with a $p\text{-value} < \alpha$. Finally, the study calculated the percent changes of new cases for each respiratory disease in response to increments of one standard deviation per pollutant. For example, it was estimated that the number of asthma cases increases 7.31% with a confidence interval of 4.31% to 10.39% when the ozone concentration increases one standard deviation (0.0089 parts per million). The estimated increase in cases of each of the diseases, analyzed by pollutant, is shown in Table 7.

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**Table 7. Mean and 95% Confidence Interval of
Increases in the Incidence of Asthma, Pneumonia,
and ARI with Increases in Pollutant Concentrations
by One Standard Deviation in the California Border
Region**

Category of Morbidity	Effect of Increase in Concentration by One Standard Deviation					
	Ozone		PM ₁₀		CO	
	Δ%	CI%	Δ%	CI%	Δ%	CI%
Asthma	7.31	4.31, 10.39	1.88	0.22, 3.57	2.30	0.06, 4.60
Pneumonia	6.34	2.66, 10.16	5.74	2.91, 8.66	7.49	3.20, 11.97
ARI	2.31	1.93, 2.69	0.40	0.12, 0.69	3.47	2.97, 3.97

ARI = acute respiratory infection

Δ = change in incidence

CI = confidence interval

Source: Universidad Autónoma de Baja California

PERCEPTIONS OF AIR QUALITY IN THE CALEXICO-MEXICALI REGION

Air quality experts and environmental and public health advocates have stressed the need for governments to resolve air quality problems in the region. But for such efforts to be successful, residents of the affected areas need to believe a problem exists and then participate in the process of developing and implementing programs to solve it.

In the late winter and spring of 2004–2005, San Diego State University-Imperial Valley Campus conducted a survey of perceptions of Calexico and Mexicali residents. Sixty-five heads of household that were designated as middle-class and/or professional were surveyed for between one to two hours each. These surveys included questions regarding their family, education, transportation, sources of news and information, activities, and opinions on various issues. The data were inputted into SPSS (a statistical analysis software) and cross-tabulated. Tables 6 through 14 provide a summary of these results.

Binational Air Quality Management

As seen in Table 8a, more than half the total residents interviewed had lived their entire lives in the region. This result, however, was significantly skewed by the Mexicali data. In Mexicali, the percentage was approximately 69% (31 of 45), whereas in Calexico it was only 25% (five of 20). Additionally remarkable is the difference between the two cities with respect to the time those interviewees who were not natives had lived locally (see Table 8b). Of the 15 in the Mexicali sample who were born elsewhere, at least nine (four did not answer this question) had lived locally for 10 or more years. Of the 14 interviewees in Calexico who were born elsewhere, only five had lived there for 10 years or more. The data from the survey, therefore, implied that the population subset that was sampled in Mexicali was much more likely to comprise long-term local residents than their counterparts in Calexico (despite the fact that Mexicali and Imperial County had similar overall population growth rates in the 1990s, as shown in Table 1).

**Table 8a. Heads of Households Native to
City/*Municipio* (Sample Size: 65)**

Category	Calexico		Mexicali		Total	
	Number of Households	Percentage of City Sample	Number of Households	Percentage of City Sample	Number of Households	Percentage of Total Sample
Lived entire life in city	5	25.0%	31	68.9%	36	55.4%
Born elsewhere	15	75.0%	14	31.1%	29	44.6%
Totals	20	100.0%	45	100.0%	65	100.0%

Source: California Center for Border and Regional Economic Studies, San Diego State University

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**Table 8b. Duration of Local Residence of
Non-Natives (Sample Size: 29)**

Length of Time in Local Area	Number of Households		
	Calexico	Mexicali	Total
Total sample	15	14	29
Less than 1 year	0	1	1
Between 1 and 2 years	1	0	1
Between 2 and 3 years	2	0	2
Between 3 and 4 years	2	0	2
Between 4 and 10 years	5	0	5
More than 10 years	5	9	14
Not answered	0	4	4

Source: California Center for Border and Regional Economic Studies, San Diego State University

As shown in Table 9, a majority of the interviewees in both cities indicated they do not ride public transportation. Considering their socioeconomic circumstances, this is not surprising.

Table 9. Households that Use Public Transportation

Use of Public Transportation	Calexico		Mexicali		Total	
	Number of Households	Percentage of City Sample	Number of Households	Percentage of City Sample	Number of Households	Percentage of Total Sample
Do use	3	15.0%	12	26.7%	15	23.1%
Do not use	17	85.0%	33	73.3%	50	76.9%
Totals	20	100.0%	45	100.0%	65	100.0%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Binational Air Quality Management

When asked what they liked about living in their respective cities (see Tables 10 and 11), more than three-fourths of the respondents in Calexico noted the peacefulness or sense of security. No single aspect drew a majority response in Mexicali, but the top three were the people, the city, and the peacefulness/security. When asked what they disliked (see Tables 12 and 13), Calexico interviewees most often (25% of them) said “nothing.” The second and third most mentioned items in Calexico were traffic and pollution (20% mentioned each). Mexicali’s respondents’ top three items were the heat (38%), dust (31%), and pollution (27%).

Table 10. What Do You Like about Living in Calexico, California?

Attribute	Number of Times Mentioned	Percentage of Respondents
Peacefulness/security	15	78.9%
Open space	5	26.3%
City	3	15.8%
People	2	10.5%
Atmosphere	1	5.3%
Family lives here	1	5.3%
Job is here	1	5.3%
Border	1	5.3%
Did not answer	1	5.3%

Source: California Center for Border and Regional Economic Studies, San Diego State University

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Table 11. What Do You Like about Living in
Mexicali, Baja California?

Attribute	Number of Times Mentioned	Percentage of Respondents
People	22	48.9%
City	20	44.4%
Peacefulness/security	15	33.3%
Atmosphere	13	28.9%
Border	10	22.2%
Family lives here	9	20.0%
Job is here	8	17.8%
Open space	5	11.1%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Table 12. What Do You Dislike about Living in
Calexico, California?

Attribute	Number of Times Mentioned	Percentage of Respondents
Heat	17	37.8%
Dust	14	31.1%
Pollution	12	26.7%
Planning for growth	8	17.8%
Traffic	7	15.6%
Crime	7	15.6%
No economic growth	3	6.7%
People	3	6.7%
Poverty areas	3	6.7%
Recreation	2	4.4%
Drug addiction	2	4.4%
Nothing	1	2.2%
School system	1	2.2%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Table 13. What Do You Dislike about Living in Mexicali, Baja California?

Attribute	Number of Times Mentioned	Percentage of Respondents
Heat	17	37.8%
Dust	14	31.1%
Pollution	12	26.7%
Planning for growth	8	17.8%
Traffic	7	15.6%
Crime	7	15.6%
No economic growth	3	6.7%
People	3	6.7%
Poverty areas	3	6.7%
Recreation	2	4.4%
Drug addiction	2	4.4%
Nothing	1	2.2%
School system	1	2.2%

Source: California Center for Border and Regional Economic Studies, San Diego State University

When asked if they crossed the border to visit the other side (see Table 14), 95% in both Calexico and Mexicali indicated they did. A follow-up question asked if they noticed any environmental differences between the two cities (Table 15). Seventy percent of the total respondents stated there were more problems in Mexicali. Approximately 25% thought both cities have about the same problems. The remaining 5% did not answer or did not have an opinion.

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**Table 14. Number of Respondents Who Cross the
Border to Visit the Sister City**

Crossing Status	Calexico		Mexicali		Total	
	Number of Households	Percentage of City Sample	Number of Households	Percentage of City Sample	Number of Households	Percentage of Total Sample
Cross	19	95.0%	43	95.6%	62	95.4%
Do not cross	1	5.0%	2	4.4%	3	4.6%
Totals	20	100.0%	45	100.0%	65	100.0%

Source: California Center for Border and Regional Economic Studies, San Diego State University

**Table 15. Perception of Environmental Differences
between Mexicali and Calexico**

Perception	Calexico		Mexicali		Total	
	Number of Households	Percentage of City Sample	Number of Households	Percentage of City Sample	Number of Households	Percentage of Total Sample
There are more problems in Mexicali	15	75.0%	31	68.9%	46	70.8%
Both cities have the same problems	4	20.0%	12	26.7%	16	24.6%
No answer/ without opinion	1	5.0%	2	4.4%	3	4.6%
Totals	20	100.0%	45	100.0%	65	100.0%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Finally, interviewees were asked what they worried about most for the future of their children (see Table 16). The majority of the residents from Mexicali (more than 51%) indicated something about the environment or the future health of their children related to the environment. The second highest response in Mexicali was safety and security. For Calexico, 45% were worried about the future of the economy and/or ability to obtain a job in the community. For responses collectively termed “other,” most related to education, which tied for second place in Calexico with safety and security. “Other” responses in Mexicali included concerns about education, cultural development, and the influence of drugs on society.

The results of this questionnaire provide insight into the communities of Calexico and Mexicali. Migration probably plays an important role in the perceptions of the residents of Calexico because many are relatively new to the city. This is supported by 2000 U.S. Census data, which indicate more than 50 percent of that city’s residents are foreign born, with approximately 88% of those coming from Mexico. Therefore, many of these individuals bring with them the perceptions of where they had lived before and compare that to their present circumstance. This could be one reason why the perceptions of the environment and of the living standards in Calexico are relatively good. In Mexicali, on the other hand, there is a much stronger perception that environmental problems exist, especially with regard to air quality. This qualitative survey is rich in information and will continue to be analyzed to understand the perceptions of local residents.

RESEARCH, ONGOING ISSUES, AND PROJECTS WITH PROMISE

To better understand the complexities of air quality in the region, a number of studies have been and are being conducted. Table 17 is not comprehensive but is illustrative of the analyses completed or currently underway in the region (and the institutions responsible for them).

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Table 16. What Do You Worry about for the Future of Your Children?

Category of Worry	Callexico		Mexicali		Total	
	Number of Households	Percentage of City Sample	Number of Households	Percentage of City Sample	Number of Households	Percentage of Total Sample
Environmental quality/health	2	10.0%	23	51.1%	25	38.5%
Economy/jobs	9	45.0%	3	6.7%	12	18.5%
No answer/ without opinion	4	20.0%	10	22.2%	14	21.5%
Other	4	20.0%	7	15.6%	11	16.9%
None	1	5.0%	1	2.2%	2	3.1%
Missing	0	0.0%	1	2.2%	1	1.5%
Totals	20	100.0%	45	100.0%	65	100.0%

Source: California Center for Border and Regional Economic Studies, San Diego State University

Table 17. Air Quality Studies Completed or Underway in the California-Baja California Region

Title of Study	Lead Institution	Date Completed
"Development of a Pollen Map for Mexicali"	Universidad Autónoma de Baja California (UABC), Mexicali	Underway
"A Poisson Regression Analysis of the Principal Respiratory Diseases and the Air Pollutants that Exceed the Air Quality Standards in Mexicali and Imperial"	UABC, Mexicali	Underway
"Program to Model and Monitor the Air Quality in Mexicali and the Imperial Valley"	Instituto Tecnológico de Estudios Superiores de Monterrey (ITESM)	Underway
"Understanding the Environmental Culture and Sustainable Behavior in the Mexicali-Calexico Region: Developing Environmental Education Products to Improve Air Quality"	The California Center for Border and Regional Economic Studies (CCBRES), San Diego State University-Imperial Valley Campus (SDSU-IV)	Underway
"Sustainable and Renewable Energy Resources for the U.S.-Mexico Border Region: Focus on the California-Baja California Border Region"	San Diego State University	2004
"Assessment of Perceptual and Objective Quality of Life Indicators in Calexico-Mexicali: Towards a Longitudinal Database for the U.S.-Mexico Border Region"	CCBRES, SDSU-IV	Underway
"Imperial Valley/Mexicali Cross Border PM ₁₀ Transport Study Report"	Desert Research Institute, J.C. Chow and J.G. Watson, University and Community College System of Nevada	1995

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Table 17. continued

Title of Study	Lead Institution	Date Completed
"Programa para mejorar la Calidad del Aire, Mexicali, 2000-2005"	Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), Gobierno del Estado de Baja California, Gobierno Municipal de Mexicali, Delegación Estatal de SEMARNAT en Baja California, Secretaría de Salud	2000
"Programa para mejorar la Calidad del Aire, Tijuana-Rosarito, 2000-2005"	SEMARNAT, Gobierno del Estado de Baja California, Gobierno Municipal de Tijuana, Instituto Municipal de Planeación, Gobierno Municipal Playas de Rosarito, Delegación Estatal de SEMARNAT en Baja California	2000
"Analyzing the Association of PM ₁₀ with Respiratory Diseases in the Populations of Mexicali, B.C. and Imperial County, CA.: A Time Series Study"	CCBRES, SDSU-IV, and UABC, Mexicali	2003
"Particulate Matter Emissions from Agricultural Burns in Mexicali/Imperial Valley Region"	University of Utah, CCBRES, SDSU-IV, and UABC, Mexicali	2003
"Understanding Quality of Life in U.S.-Mexican Border Region: A Case Study of Imperial Valley-Mexicali"	CCBRES, SDSU-IV, and UABC	2003
"Contributions of Organic Compound Pollutants to Ozone and Fine Particulate Matter in Mexicali"	Arizona State University and ITESM	2005

Source: Author

Issues Related to Capacity and Data

Although a number of studies have been undertaken, there is still a lack of quality-assured data, laboratory equipment, and training. Additionally, there is a lack of human capital; only a handful of people are working on air quality in the region. Most importantly, air quality projects are done “on the cheap.” Funding is insufficient to explore adequately how to improve air quality, especially in the Imperial Valley and Mexicali.

One of the largest deficiencies is the lack of data that can be statistically validated and that are in a format comparable to data from the other side of the border. This is especially true for health-related data. If analysts and the public are to have a useful understanding of the relationship between air contaminants and respiratory illnesses, there must be similar and comparable sources of reliable data on the health of individuals living in the border region. From the data that do exist, some correlations have been developed, but these are not optimal. The next section discusses in further detail the known relationships between air quality and respiratory health.

Additional information also is needed on the source identification and quantification, as well as on the atmospheric chemistry that produces the particular ambient concentrations measured, especially with regard to ozone. Researchers are currently engaged on these topics to a greater degree in Mexicali and Imperial than in the other urban areas of the region.

Despite their best intentions, local researchers and grant-making institutions such as the Southwest Consortium for Environmental Research and Policy (SCERP) and Academic and Professional Programs for the Americas (LASPAU) are limited by deficiencies in local infrastructure and in agreements to standardize or establish binational procedures in the normalization of data collection. This is especially true for quality-assured binational clinical data, although there are also issues regarding the binational air pollution data. Without a strong, reliable source of data, research in the region is difficult. The following two subsections identify local challenges to conducting epidemiological and ecological studies about the relationship between pollution and health effects.

Air Pollution Issues

Deficiencies exist with respect to both the infrastructure and the available data. With regard to infrastructure, there are problems in three categories. First, there is insufficient equipment for monitoring air pollution and meteorological variables. Second, there is lack of capacity to examine and validate the atmospheric information produced and collected by non-local institutions. Third, there is a problem with accessing materials and equipment that would allow for better experimental designs and quality assurance of samples—for example, a certified air laboratory with capacity for equipment calibration and material conditioning under the appropriate norms.

The data that are available from official institutions fall short in at least two ways. One is that hourly information sometimes cannot be obtained, which makes it difficult to carry out experiments and analysis at a lower resolution. A second problem is that information from some environmental monitoring stations is missing and others have irregularities in their registers; this situation limits geographic sector research, which is particularly problematic in a binational region.

Health Issues

For health data to be optimally useful, more extensive and intensive information needs to be collected. First, it would be helpful to standardize the collection of data on cardiorespiratory and cardiovascular diseases in the border region. These diseases have a documented relationship to air pollution. In Mexico, for example, new case records of mortality and morbidity are reported on a weekly basis. In order to conduct an analysis at a finer resolution, it would be helpful to have a record of mortality and morbidity counts by the hour, or at least on a daily basis. Another inconsistency between the United States and Mexico is that bronchitis is registered by Mexican doctors within the broad disease category ARI. In the United States, respiratory illnesses are categorized separately, though there are some issues in the diagnosis.

Secondly, critical contextual information related to disease diagnoses needs to be recorded and reported. In Mexico, new cases of mortality and/or morbidity only include the disease diagnosis; demographic and geographic aspects of the patient are not recorded. This lack of data makes it difficult to correlate other factors such as location, gender, and age.

If these challenges are not addressed, it will be nearly impossible to carry out projects in this binational region equal in sophistication and usefulness to those being conducted elsewhere. For example, since the 1980s a European project titled *Air Pollution and Health—A European Approach* (APHEA) (Katzouyanni 1997) has studied the short-term effects of air pollution on health in a number of countries in that region. A second and more recent European project titled *Estudio Multicéntrico Español sobre la Relación entre Contaminación Atmosférica y Mortalidad* (in English the *Spanish Multicenter Study on the Relationship Between Atmospheric Pollution and Mortality*) began in 1997. The title was changed in 2000 to the Spanish equivalent of the *Spanish Multicentric Study on the Relationship Between Atmospheric Pollution and Health*. (RedIRIS 2006) when the number of hospitalizations was added to the mortality data. Similarly, researchers in the United States have developed comparable projects such as the National Morbidity, Mortality and Air Pollution Study (Samet 2000).

For the border region, it would be extremely helpful to reach a binational agreement that permits projects of this magnitude. There is a need for projects that analyze both sides of the border and that generate results with a high level of confidence. Such projects are needed not only on the subject of the health effects of air pollution, but also regarding water and soil contamination. Only this approach will produce an understanding of how pollution affects human health that can adequately inform policymakers as they grapple with the challenge of designing effective policies and programs.

Projects Under Way

In response to the recognition that large amounts of PM were being generated from unpaved roads in Baja California, the Dirección de Ecología Estatal de Baja California worked with SEMARNAT and

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the North American Development Bank (NADB) to secure funding for road paving. In 2003 this project received the necessary certification from the Border Environment Cooperation Commission and then partial financing from NADB for the purpose of improving the health of the local residents. A NADB press release described the program as follows (NADB 2003):

PIPCA [Programa Integral de Pavimentación y Calidad del Aire, in English the Air Quality Improvement and Street Paving Program] is a multiphase program aimed at paving 14.9 million [square meters] m^2 (equivalent to about 926 miles) of street surface area in the municipalities of Tijuana, Mexicali, Ensenada, Tecate and Playas de Rosarito over a four and a half year period ending in December 2007. Full implementation of the project is expected to increase the pavement coverage of all urban streets in the state from around 59% to 80%.

The first phase of PIPCA will pave an estimated 2.3 million m^2 of streets in the five communities over an 18-month period:

- Tijuana: 1,003,000 m^2
- Mexicali: 484,000 m^2
- Ensenada: 352,000 m^2
- Rosarito: 345,000 m^2
- Tecate: 124,000 m^2

Subsequent to the financing, Baja California Governor Eugenio Elorduy declared in his Third Report of Government that a total of 812,060 m^2 had been paved from October 2003 to September 2004, representing an investment of 191,458,000 pesos (approximately \$19 million) (Elorduy 2004). Of this total amount, Mexicali accounted for 48.7 million pesos (approximately \$4.5 million) and for a paved surface area of 111,634 m^2 .

In 1996 Mexicali had unpaved streets covering an area of 7.79 million m^2 , equivalent to 38% of the total urban surface. Paving of those streets did not begin until late 2003 (after NADB financing was approved), which could help explain why the PM_{10} levels were

not falling appreciably over time, as seen in Table 6. The first year of the program reduced the unpaved surface area in Mexicali by just 0.54%.

At least two pollution-reduction programs have been implemented across the border in the Imperial Valley. The Emission Reduction Program for Agricultural Burning consists of giving a certificate to farmers who agree not to burn their agricultural residues. Those farmers can then sell the certificate to stationary plants in the Imperial Valley who need to reduce their emissions.

The Carl Moyer Memorial Air Quality Standards Attainment Program (applicable statewide in California and initiated in 1998), provides grants to reduce exhaust emissions from heavy-duty diesel engines. Funding is available for projects to replace diesel engines with new, cleaner engines within existing equipment; to retrofit existing diesel engines with emission control devices; and to purchase new vehicles or equipment with emissions below applicable state and federal standards. In Imperial County in 2005 this program invested \$100,000, and for 2006 the figure is \$356,000 (the latter includes a \$100,000 match by the county) (California Air Resources Board 2004).

In San Diego, financial incentive programs augment traditional control programs to further encourage technology development and provide cost-effective emission reductions not easily achieved by regulations. Eight incentive programs have been implemented in San Diego County in recent years (San Diego County Air Pollution Control District 2004):

- Carl Moyer Program
- Vehicle Registration Fund Program
- Lower Emission School Bus Replacement and Retrofit Program
- Emission Reduction Credit Bank For Peaking Powerplants Program
- Heavy-Duty Diesel Vehicle Retrofit Program
- Back up Generator Mitigation Funds Program
- Congestion Mitigation and Air Quality Improvement Program
- Lawnmower Exchange Program

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In addition, the San Diego/Tijuana Clean Diesel Demonstration Project, partially funded by EPA under the Border 2012 Program, focuses on diesel emission reduction technologies for Mexican heavy-duty trucks. It will be implemented in two phases: diesel oxidation catalysis ($\geq 25\%$ PM reduction) and diesel particulate filters ($\geq 85\%$ PM reduction, which requires ultra low sulfur diesel).

ELECTRICITY AND NATURAL GAS ISSUES

The California-Baja California border region has become a focal point for the development of energy infrastructure in the aftermath of the deregulation of power markets in the United States and the liberalization of energy supply in Mexico. Baja California is viewed by proponents of international power and liquefied natural gas (LNG) as an excellent site for projects destined to serve the California market. Such development has significant implications for air quality, as explained in more detail below. In response, strong grassroots movements questioning the strategic need for this infrastructure and demanding higher environmental standards for projects have developed on both sides of the border. These groups have recommended, as an alternative, an accelerated commitment to energy efficiency and renewables in the region, combined with a gradually declining use of domestic natural gas that provides for future growth in energy demand without further compromising regional air quality.

Power Plants

Reducing the generation of NO_x , a precursor in ozone formation, is necessary to solve important aspects of the air quality problems in the California-Baja California border region. One source of NO_x is electricity generation using fossil fuels. Reduction must come from both retrofitting existing plants and from minimizing the emissions of new plants. Citizen activism and resulting governmental pressure have enjoyed some recent successes in this regard.

As of 2005, there were 13 major power generation units (nine utility boilers and four gas turbines) located either in San Diego County or exclusively exporting from Mexicali to the California

power market via San Diego County. Only five of them (three utility boilers and two gas turbines) would be equipped with advanced catalytic NO_x control systems had it not been for direct, vocal, and relentless community pressure. Now all 13 plants have the technology.

In the case of the 1,000 megawatt (MW) Encina Power Plant in Carlsbad (in northern San Diego County), the city and local citizens applied sufficient pressure on regulators to ensure all five of the plant's utility boilers were retrofitted with advanced NO_x controls between 2001 and 2003.

Mexicali is the site of two new 600 MW gas turbine combined-cycle power plants owned by Sempra Energy and InterGen, respectively (the plants began exporting power to California in mid-2003). As pointed out earlier in this chapter, neighboring Imperial County is a nonattainment area for ozone and Mexicali's ambient concentrations would lead to a similar designation if Mexico had a system for such determinations. Existing data indicate a high level of pulmonary disease in the area.

Sempra's stated purpose for constructing the export plant in Mexico is "availability of low-cost labor, avoiding some of the stringent environmental rules for new U.S. facilities, and permitting for a new plant takes only 6 to 8 months compared to much longer periods to gain approvals for U.S. projects" (Gas Turbine World 2004). An additional economic reason is that Mexico does not have "offset" requirements—the United States requires that owners of a new emissions-generating facility in an area with pollution problems pay for an equal or greater reduction of emissions in that area.

The Presidential Permits issued by the U.S. Department of Energy (DOE) that are necessary to import power from these two plants to the United States were revoked in May 2003 by a federal court. The court ruled DOE conducted an inadequate environmental assessment prior to issuing the permits. The case is still in progress. A major issue in the case is the need for emission offsets in the shared airshed.

Beyond the issue of offsets, InterGen had not originally planned to install any advanced NO_x controls on the four turbines at its Mexicali plant. After receiving considerable pressure from citizens and government agencies in Imperial County, the company agreed to

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install the technology on the two turbines generating electricity for export. Later, responding to pressure from Senator Diane Feinstein and Congressman Duncan Hunter, InterGen also volunteered to install such controls on the remaining two turbines at the plant, which serve the Mexican domestic market. InterGen recently completed these installations, but is attempting to pass on the cost to Mexico's Comisión Federal de Electricidad (CFE). This issue is currently before an international arbitration tribunal in Paris. Congressman Bob Filner (representing part of San Diego County and all of Imperial County) attempted unsuccessfully to amend the energy bill before Congress in 2005 to require that any power plant exporting power to the United States with 25 miles of the border meet all requirements of the adjacent U.S. air district.

Transmission Lines

Although the two Mexicali plants have a combined capacity of 1,200 MW, the two transmission lines connecting the Mexicali export plants to the Imperial Valley are each capable of carrying up to 1,200 MW. There is concern in both the Imperial Valley and Mexicali that additional export plants will be built in Mexicali to take advantage of the transmission capacity.

However, the only outlet for this power at present is San Diego, using the 500 kilovolt (kV) transmission trunkline known as the Southwest Power Link (SWPL) that connects power plants in western Arizona (Palo Verde) with San Diego. On peak demand days, SWPL operates near its 2,800 MW carrying capacity, limiting the additional amount of power that can be exported from Mexico. There are also two existing 230 kV lines in Mexico that run parallel to the border, but these lines are currently limited to 800 MW of capacity and would have to be upgraded to serve as a viable alternative to the SWPL for the export plants.

Currently, San Diego Gas & Electric (SDGE) is in the initial stages of proposing a greenfield 500 kV transmission line that would run from the Imperial Valley to the Southern California Edison (SCE) system via the San Diego County backcountry. This line

would allow the export plants in Mexicali to reach a wider market, as well as offer a pathway for exploiting wind energy potential straddling the border in eastern San Diego County.

The 500 kV line proposed by SDGE follows the “wholesale electricity markets” concept of long-range transport of electricity to allow electricity consumers access to least-cost generation (in theory). A greenfield 500 kV line between the SCE system and western Arizona power plants was recently approved at an estimated cost of \$700 million. Presumably the other greenfield 500 kV line proposed by SDGE would also cost in the range of \$700 million when fully interconnected with the SCE system.

The San Diego area was especially hard-hit by the economic chaos caused by California’s 2000–2001 electricity crisis. The response of the San Diego political, business, and public-interest community was to develop a strategic energy plan to minimize the possibility of that experience repeating itself. The product of this multi-year effort was the *San Diego Regional Energy Strategy 2030*, published in July 2003 (Regional Energy Policy Advisory Committee 2003). This blueprint emphasizes local control of power assets, accelerated development of renewable energy in the San Diego region, and inclusive planning in energy matters. It offers a sharply different vision of the future than the wholesale power markets’ vision, with its emphasis on transmission superhighways. The *San Diego Regional Energy Strategy* suggests a “local control” alternative to the proposed greenfield 500 kV line. It proposes upgrading the two 230 kV lines in Mexico from 800 MW to 2,000 MW to assure the reliability of access to the two export plants in Mexicali. Those two plants would be incorporated into the SDGE system.

CFE projects it will construct 1,000 MW of additional baseload (combined-cycle) power plants in Baja California over the next 10 years, in 250 MW increments, as well as 500 MW of simple-cycle peaking plants (Moya 2004). At present, it appears these projects will be built near the principal demand centers of Tijuana and Mexicali, thus minimizing the amount of additional transmission capacity needed.

Liquefied Natural Gas Terminals in Baja California

The initial rush of liquefied natural gas proposals on the West Coast was focused on Baja California, where six LNG terminal proposals were active in 2002. Community opposition derailed two proposals, the El Paso/ConocoPhillips proposal in Rosarito and the Marathon proposal in Playas de Tijuana. Two projects were consolidated into one—the Semptra/Shell Costa Azul LNG terminal. The two additional active LNG terminal proposals in Baja California are the ChevronTexaco offshore artificial island project just below the border, and the Terminales y Almacenes Marítimos de México, SA de CV (TAMMSA) floating offshore project near Rosarito.

The design baseload throughput of one LNG terminal is 1 billion cubic feet per day. Semptra has claimed it will supply half its LNG throughput to Baja California at startup in 2008 and all throughput to Baja by 2015 (Semptra 2004). ChevronTexaco has stated it will supply 70% of its throughput to Baja California at startup in 2008. But the current natural gas demand in Baja California (currently supplied from the United States) is only 85 million cubic feet per day (Moya 2004) and CFE's projections have led it to commit to purchase an average of 130 million cubic feet per day from the Semptra/Shell Costa Azul LNG terminal. This is the only contract announced by the project developers to date. It is unclear, therefore, who the customers are that would comprise the Baja demand projected by Semptra and ChevronTexaco. A more likely scenario is that 90% of the LNG throughput of the Semptra/Shell LNG terminal and 100% of the ChevronTexaco LNG terminal will go to California if these projects are built.

The LNG terminals in Baja California have been controversial because of the risk posed to surrounding populations, the marine impacts of seawater regasification, and incompatible land use. LNG terminals also have the potential to be major sources of air pollution. For example, a ChevronTexaco facility identical to the Baja California proposal but proposed for the Gulf of Mexico has listed potential NO_x emissions of approximately 1,000 tons per year (U.S. Coast Guard 2003). The ChevronTexaco Baja terminal will be approximately 20 miles from downtown San Diego.

The San Diego region and Baja California currently receive all their natural gas from U.S. domestic sources. DOE estimates the United States has at least 60 years of natural gas reserves using existing technology. However, it appears that major oil companies and the federal government are now working against small- and medium-sized independent producers to ensure domestic gas production does not derail LNG import schemes. Multinational oil companies are no longer big players in domestic exploration and production. The DOE announced in February 2005 it was terminating all funding for research and development activities related to oil and natural gas. Independent producers are too small to carry out their own research and development.

The problem for multinational oil companies eager to enter the LNG import business in Baja California is that LNG does not appear to be economically feasible on the West Coast in a rational natural gas market. The average production cost of domestic gas resources is well under \$3 per million British thermal units (MMBtu). The cost to land LNG on the West Coast is at least \$3.50/MMBtu and potentially more than \$4/MMBtu. The current high natural gas prices mask the relative uncompetitiveness of LNG on the West Coast. Natural gas prices have been increasing despite good balance between supply and demand, increasing production, higher rig counts, robust storage, and relatively flat demand. This indicates a flawed market, not domestic gas shortages or permanently high domestic gas prices. If the principal flaws are resolved in the short term—a terrorism (fear) surcharge, trading dominated by speculators, and associated market volatility—LNG will be much less attractive as a substitute for domestic natural gas.

The big-picture view on domestic natural gas and LNG articulated in a technical assessment recently featured in the Natural Gas Intelligence e-newsletter is instructive (Choukas-Bradley 2005):

We do not see the level of increased domestic production activity from the international majors and certain large North American independents that we would expect to see in a rational, competitive marketplace at current gas prices. The flight overseas of dollars earned by producers from domestic gas prices realized since 2000 ... effectively means that the American consuming public is financing

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international projects ... the multinationals appear to be taking the “windfall” profits from high domestic gas prices to invest in overseas projects largely owned by foreign national oil companies (willing to accept as little as \$0.50/MMBtu for stranded gas) that they believe offer better investment opportunities ... Such activity, in turn, helps to support the continued high level of domestic gas prices by resulting in a reduced level of domestic production ... In addition, such producers have made a major commitment to the exploitation and importation of LNG to the domestic market in order to capture the benefits of enhanced investment returns in foreign projects, particularly those that are largely dependent on the greater domestic prices, and at the same time have succeeded in selling that program as the domestic market’s savior.

The California Public Utilities Commission (CPUC) also made a key decision in favor of LNG imports in September 2004. While highlighting the need to promote natural gas supply diversity to ensure reliability of supply to California, state regulators inexplicably authorized Southern California Gas Company and SDGE (both owned by Sempra) to terminate 1.4 billion cubic feet per day of existing natural gas capacity contracts with two of the four North American natural gas supply basins serving California; 1.4 billion cubic feet per day is sufficient baseload throughput for nearly one-and-a-half LNG terminals. Natural gas supply companies warned against this action as being contrary to the stated purpose of ensuring reliability of supply. This step artificially creates a market for new natural gas supplies in California, even though California’s natural gas demand has declined nearly 20% since 2001. The fact that CPUC felt compelled to create an artificial market for LNG underscores the unfavorable economics of importing LNG to the West Coast (in a competitive natural gas market). This CPUC decision is under appeal.

The Best Answer—Energy Efficiency/ Renewables/Domestic Natural Gas

California's May 2003 Energy Action Plan explicitly prioritizes energy efficiency and renewable sources over increased dependence on natural gas. Other border governors, responding to California Governor Arnold Schwarzenegger's call, have officially declared their commitment to maximize the use of energy efficiency and renewable energy in the border region. Reaching the ambitious renewable and efficiency targets would have a dramatic effect on natural gas demand. The California Energy Commission is assisting in implementing a legislative mandate to achieve a 20% penetration by renewables by 2020.

CONCLUSIONS AND RECOMMENDATIONS

The California-Baja California border region is dynamic and complex, with a significant concentration of population in San Diego-Tijuana and a secondary concentration in Calexico-Mexicali. It is difficult to characterize the entire region uniformly because there are such large differences in climate and other environmental conditions and economic activities. But each of those two population centers comprises a pair of sister cities that form a common airshed. The counties and municipalities, with appropriate cooperation from their respective state and national governments, need to work together to overcome the challenges and improve the quality of life throughout the region.

This final section summarizes a set of recommendations stated or implied in the more detailed analysis above.

Generation, Availability, and Comparability of Data and Other Information

- Establish common formats for monitoring and reporting air emissions in the border region; this will make the data more compatible across the border and more accessible to a broader audience, particularly state and local governments

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- Identify, collect, coordinate, and disseminate several types of air quality and public health information

Policies and Programs (general)

- Help policymakers identify and focus on air quality reduction programs for pollutants and sources that pose the greatest public health risk
- Encourage the adoption of a single-airshed approach to each of the sister-city pairs
- Encourage greater harmonization of regulatory frameworks between the United States and Mexico
- Implement public health and air toxics reduction projects for well known problems (such as reduction of PM or characterization of pollen in the border region to prevent allergies) rather than develop additional metrics
- Establish contingency plans in the case of high pollutant events in collaboration with various government institutions in order to protect the community
- Involve academic institutions in air quality research

Clean, Efficient Transport

- Harmonize vehicle inspection and maintenance programs
- Establish a binational vehicle registry to track used vehicle importation into Mexico
- Develop diesel emissions control and mitigation programs for mobile sources and non-road diesel engines

Clean, Efficient Energy Generation, Transmission, and Use

- Coordinate and advocate for efforts to strengthen and harmonize the regulatory framework regarding energy efficiency, including standardizing requirements for energy generation plants within the border region

- Analyze and highlight differences and opportunities on each side of the border for improving air quality through the permitting of stationary sources
- Develop the infrastructure on the Mexican side for more natural gas use in the community and the industry (if the natural gas market prices do not rise too high)

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II

A Tale of “Three” Cities: Air Quality Improvement Efforts in the Arizona-Sonora Border Region

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ABSTRACT

This chapter compares and contrasts air quality improvement efforts in three pairs of sister cities along the Arizona-Sonora border: Douglas-Agua Prieta, Ambos Nogales, and Yuma-San Luis Río Colorado (SLRC). Several patterns of successes and challenges emerge, pointing to various lessons of relevance to the rest of the U.S.-Mexican border.

These sister cities share common sources of particulate matter (PM) pollution, which is the most important air pollutant impacting public health along the Arizona-Sonora border. Major sources of PM pollution include unpaved roads, vehicle emissions, traffic congestion, soil erosion, and residential burning of garbage and wood. Emissions from agricultural tilling and agricultural burning practices are an important source in Yuma-SLRC.

Binational Air Quality Management

Air quality monitoring and air quality trends are quite different in each sister city pair. Douglas has complied with applicable air quality standards for PM₁₀ and PM_{2.5} (PM that measures 10 microns and 2.5 microns or less in diameter, respectively). Agua Prieta shows PM₁₀ violating the applicable air quality standards (Mexican Allowable Limits). Yuma is being reclassified from a nonattainment area to a maintenance area.

While Nogales, Arizona, has not violated the annual PM₁₀ standard since the early 1990s, it has shown an upward trend since 1997. In Nogales, Sonora, both the 24-hour PM₁₀ concentrations and the annual averages are generally slightly higher than those in Nogales, Arizona, with the allowable limits regularly being violated.

Binational air quality studies are at various stages of work in each of the three sister-city pairs. The binational study for Ambos Nogales was published in 1999; in Douglas-Agua Prieta, the monitoring and emissions inventory have been completed; and in Yuma-SLRC meteorological data collection has begun.

It has been possible to conduct the binational air studies with the same phases in each area. Differences in population and economic growth, as well as air quality compliance status and trends over time, however, will require different approaches to emissions reduction activities in each of the three areas.

Several interesting conclusions emerge from comparing the experiences of these three sister-city pairs. Most importantly, social infrastructure has been a common element in successful efforts. Social infrastructure is the networks of people and institutions that work together toward a common goal. Where relevant, established social infrastructure, exists local leadership to implement air quality improvement actions comes along naturally. Another key factor is effective public outreach. One important, common experience of successful social infrastructures working on air quality in the Arizona-Sonora border region is that local Sonoran residents have participated in these collaborative efforts as equal partners to their Arizona counterparts.

This chapter notes that each major emissions source exists in its own framework of laws, policies, social driving forces, levels of relevant governmental authority, and the roles of individuals. To address any source successfully, the participants in that effort must

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first fully understand that framework, but then must also exercise out-of-the-box thinking about the particular emissions source in question. Second, the design and targeting of emissions reduction activities is something that can be effectively controlled by local participants, with measurable air quality improvements possible as a result. Third, other important factors affecting air quality are often beyond local or even state-level participant's control, in particular, weather patterns, population growth, and economic growth. Fourth, because national policy initiatives often tend to be informed by a perspective that focuses on the grand scale and large populations, the needs of rural areas can be overlooked or lost amid the many competing priorities.

Finally, while financing air quality projects is essential to real success, it is not necessarily the first step. The effective establishment of a relevant social infrastructure may be essential prior to obtaining and effectively using substantial levels of funding and essential to the long term success of any project.

Historia de “Tres” Ciudades: Esfuerzos para mejorar la Calidad del Aire en la Región Fronteriza Sonora-Arizona

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RESUMEN

Este capítulo compara y contrasta los esfuerzos para mejorar la calidad del aire en tres pares de ciudades hermanas a lo largo de la frontera de Sonora-Arizona: Agua Prieta-Douglas, Ambos Nogales, y San Luis Río Colorado (SLRC)-Yuma. Surgen diversos patrones de éxitos y retos que apuntan a varias lecciones de relevancia para el resto de la frontera de México-Estados Unidos.

Estas ciudades hermanas comparten fuentes comunes de contaminación provenientes de materia particulada (PM, por sus siglas en inglés), la cual es el contaminante más importante del aire que impacta la salud pública a lo largo de la frontera de Sonora-Arizona. Las fuentes principales de contaminación de PM incluyen las calles sin pavimentar, las emisiones vehiculares, la congestión del tráfico, la erosión del suelo y el quemado de basura residencial y madera. Las emisiones de las prácticas de cultivos y quema agrícolas, son fuentes importantes en SLRC-Yuma.

El monitoreo de la calidad del aire y las tendencias de la calidad del aire son bastante diferentes en cada par de ciudades hermanas. Douglas ha cumplido con los estándares aplicables de la calidad de aire para PM₁₀ y PM_{2.5} (PM que mide 10 micrones y 2.5 micrones o menos en diámetro, respectivamente). Agua Prieta muestra que el

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PM₁₀ viola los estándares aplicables a la calidad del aire (Límites Permisibles en México). Yuma está en proceso de reclasificación de ser un área de no cumplimiento a ser área en mantenimiento.

Aunque en Nogales, Arizona no se han violado los estándares anuales para PM₁₀ desde principios de la década de 1990, sí ha mostrado una tendencia ascendente de PM₁₀ desde 1997. En Nogales, Sonora, tanto las concentraciones de PM₁₀ durante 24 horas como los promedios anuales son por lo general ligeramente más altos que aquellos en Nogales, Arizona, con los límites permisibles regularmente violados.

Los estudios binacionales de la calidad del aire se encuentran en diversas fases de trabajo en cada uno de los tres pares de ciudades hermanas. El estudio binacional de Ambos Nogales fue publicado en 1999; en Agua Prieta-Douglas, el monitoreo y el inventario de emisiones han sido completados; y en SLRC-Yuma la recopilación de información meteorológica ha sido iniciada.

Ha sido posible llevar a cabo los estudios binacionales del aire con las mismas fases en cada área. Sin embargo, las diferencias y el crecimiento poblacional y económico, así como el estado de cumplimiento y tendencias en el área de la calidad del aire a través del tiempo, requerirán diferentes enfoques de las actividades para la reducción de emisiones en cada una de las tres áreas.

Diversas conclusiones interesantes emergen al comparar las experiencias de estos tres pares de ciudades hermanas. Lo más importante, la infraestructura social ha sido un elemento común en los esfuerzos que han sido exitosos. La infraestructura social es la red de personas e instituciones que trabajan conjuntamente hacia un fin común. En donde existe una infraestructura social relevante y establecida, el liderazgo local para implementar las acciones para mejorar la calidad del aire se da de manera natural. Otro factor clave es un enlace comunitario efectivo. Una experiencia importante y común de las infraestructuras sociales, es que trabajan en la calidad del aire en la región fronteriza de Sonora-Arizona, es que los residentes locales de sonorenses han participado en estos esfuerzos de colaboración como socios iguales a sus homólogos en Arizona.

Este capítulo establece que cada fuente prioritaria de emisiones existe en su propio marco jurídico, políticas, matrices, niveles de autoridad gubernamental relevante y el desempeño de los

individuos. Para poder abordar cualquier fuente exitosamente, los participantes en ese esfuerzo deberán primero entender completamente ese marco, pero después también deberán pensar fuera de ese marco opiniones sobre la fuente particular en cuestión. Segundo, el diseño y enfoque de actividades de reducción de emisiones es algo que los participantes locales pueden controlar de modo eficaz con mejoras en la calidad del aire que se pueden medir. Tercero, otros factores importantes que afectan la calidad del aire están fuera del control de la participación ciudadana local y hasta estatal, en particular, en patrones meteorológicos, crecimiento poblacional y crecimiento económico. Cuarto, ya que las iniciativas nacionales de políticas por lo general tienden a estar informadas por una perspectiva que se enfoca en la gran escala y poblaciones numerosas, las necesidades de las áreas rurales pueden pasar desapercibidas o perderse entre las diversas prioridades en competencia.

Finalmente, mientras que el financiamiento de los proyectos de la calidad del aire es esencial para el éxito real, no es necesariamente el primer paso. El establecimiento eficaz de una infraestructura social relevante puede ser esencial previo a obtener y usar efectivamente niveles substanciales de financiamiento y esencial para el éxito a largo plazo de cualquier proyecto.

INTRODUCTION

Geography of the Arizona-Sonora Border Region

The Arizona-Sonora border region can best be described as a set of three primary sister-city pairs in relatively concentrated development along the border with vast stretches of very sparsely developed rural lands in between and a number of smaller municipalities and towns farther away from the border but still within the 100-kilometer (km) border zone in both countries. A significant portion of this border region in Arizona is composed of the rural Tohono O'odham Nation, which shares the longest tribal border with Mexico along the entire binational boundary.

A Tale of "Three" Cities: Air Quality Improvement Efforts in the Arizona-Sonora Border Region

The Arizona-Sonora border region is arid desert, although significant variations in elevation lead to large differences in local climate and ecosystems. These differences have direct influences on air quality. Population and economic activity are increasing in this border area, although these increases are concentrated in the sister-city pairs of (from east to west) Douglas, Arizona-Agua Prieta, Sonora; Ambos Nogales (the name for the cities of Nogales, Arizona, and Nogales, Sonora); and Yuma, Arizona-San Luis Río Colorado (SLRC), Sonora. The Arizona-Sonora border is approximately 20% of the total length of the U.S.-Mexican border.

DIFFERENCES AND PARALLELS BETWEEN SISTER-CITY PAIRS: AN OVERVIEW

Douglas-Agua Prieta

Douglas and Agua Prieta are located in a relatively flat area on the eastern slope of what on the Arizona side is called the Sulphur Springs Valley. They are at an elevation of 4,000 feet, surrounded by several mountain ranges whose closest points are between 6 km and 50 km from the urbanized area (depending on the direction, and closest on the eastern side).

Summer temperatures in this arid region typically reach highs of slightly over 100°F, while winter lows typically dip below freezing on several occasions every year. The Western Regional Climate Center at the Desert Research Institute reports annual average precipitation in Douglas to be 14.52 inches, based on data spanning the years 1948 to 2002 (Western Regional Climate Center No Date). As with much of southern Arizona and northern Sonora, the Douglas area receives this precipitation primarily during summer monsoons, secondarily during gentle winter rains, and rarely outside of these two seasons. The predominant wind direction is from southwest to northeast; because of the locally flat topography and the close proximity of the two communities, air quality in the two communities is quite similar.

Violations of the U.S. particulate matter (PM) standards in the late 1980s and early 1990s led to the federal designation of two small and localized nonattainment areas: Douglas and Paul Spur (a

lime plant on the outskirts of Douglas). PM emission sources in the Douglas-Agua Prieta area are similar in nature, although not identical with respect to relative source contributions, to those in Ambos Nogales.

As with all sister-city pairs along the Arizona-Sonora border (Table 1), the Sonora side has a much larger population than the Arizona side. According to the Instituto Nacional de Estadística Geografía e Informática (INEGI), the population of Agua Prieta was 61,944 in 2000 (Gobierno del Estado de Sonora No Date-a), although local residents believe the actual population is closer to 110,000. The Arizona Department of Economic Security (ADES 2004) estimated the population of Douglas to be 16,740 in 2004.

Table 1. Population of Border Cities in Arizona and *Municipios* in Sonora

State	City/Municipio or Native Community	Population
Arizona	Douglas	16,740
	Nogales	21,375
	Yuma	86,070
	San Luis	21,180
	Somerton	8,855
	Naco	1,000
	Tohono O'odham Nation	24,000
Sonora	Agua Prieta	61,944
	Nogales	159,787
	San Luis Río Colorado	145,006
	Naco	7,000

Sources: Arizona Department of Economic Security and Instituto Nacional de Estadística Geografía Informática

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Primary economic activities in the sister cities include customs brokerage services, the maquiladora sector, tourism, and local government and school employment. Although mining activities used to be locally important, the closure of several mines in both Arizona and Sonora has resulted in mining losing much of its importance for the local economy. A projected expansion of the power generation plant in Agua Prieta, however, will likely mean this sector of employment will gain increasing importance in coming years. The maquiladora sector has suffered a downturn recently, with the number of maquiladoras in Agua Prieta dropping significantly from a high of 34 in 2001 to 21 in 2003, and then to 20 in 2004 (Austin, et al. 2004).

In percentage terms, projected population growth rates in the two communities are moderately high. Because the communities are small to begin with, however, the projected future total populations are not expected to become very large when compared with Ambos Nogales or Yuma-SLRC. Because of its relatively small population, Agua Prieta has struggled to install basic infrastructure. As a result, unpaved roads are a dominant feature. Compared with Ambos Nogales, the relatively smaller size and projected growth rates of Douglas-Agua Prieta are likely due to the fact that Douglas and Agua Prieta are much farther away than Ambos Nogales from major cities located within the interiors of both states, such as Tucson and Phoenix in Arizona and Hermosillo in Sonora.

AMBOS NOGALES

Nogales, Arizona, at an elevation of 3,900 feet, has an ecosystem quite similar to that of Douglas-Agua Prieta. Summertime highs also typically peak at slightly over 100°F, and winter lows also dip below freezing several times each year. The Western Regional Climate Center at the Desert Research Institute reports annual average precipitation in Nogales to be 16.57 inches, based on data spanning the years 1948 to 1983 (Western Regional Climate Center No Date), making Ambos Nogales a slightly wetter area than Douglas-Agua Prieta. As with much of southern Arizona and northern Sonora, the Nogales area receives this precipitation primarily during summer monsoons, secondarily during gentle winter rains, and rarely outside

of these two seasons. As in Douglas-Agua Prieta, the predominant wind direction is from southwest to northeast. However, certain characteristics of Ambos Nogales' geography are quite different from Douglas-Agua Prieta.

Unlike Douglas-Agua Prieta, Ambos Nogales is located within a narrow, north-south trending mountain valley. Peaks rise several hundred feet above the average elevation, and weather systems as well as stormwater runoff events can be more extreme than in Douglas-Agua Prieta because of this topography. Nevertheless, like Douglas-Agua Prieta, both communities in Ambos Nogales share many air quality characteristics. Due to violations of the air quality standards for PM in the late 1980s and early 1990s, the U.S. Environmental Protection Agency (EPA) designated the entire city of Nogales, Arizona, and a small portion of Santa Cruz County (primarily the southern half of unincorporated city Rio Rico, Arizona) as the Nogales Nonattainment Area. Primary sources of PM emissions in Ambos Nogales are unpaved roads and parking lots, vehicle emissions from passenger vehicles and heavy duty diesel vehicles, traffic congestion, soil erosion, and the residential burning of wood and garbage.

Ambos Nogales is the Arizona-Sonora sister-city pair with the largest populations and the highest levels of economic activity. According to INEGI, the population of Nogales, Sonora, in 2000 was 159,787 (Gobierno del Estado de Sonora No Date-b), although many local residents believe the actual population to be much higher—perhaps as great as 350,000. According to ADES, the population of Nogales, Arizona, was approximately 21,375 in 2004. It should be noted that there is a significant floating population in Nogales, Arizona. The U.S. Bureau of Customs and Border Protection estimates that approximately 40,000 people cross the border from Nogales, Sonora, into Nogales, Arizona, legally on a daily basis, and then return to Nogales, Sonora, on the same day.

The most important economic activities in Ambos Nogales are in the produce, maquiladora, customs brokers, and tourism sectors. It has been estimated that up to 70% of all fresh produce consumed in the entire United States and Canada during winter months is grown in Mexico and imported through Nogales. As in Agua Prieta, the maquiladora sector has suffered a downturn in recent years in

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Nogales, Sonora, going from a high of 109 maquiladoras in 2001 to a low of 73 in 2002. Unlike Agua Prieta, however, Nogales has started to see some recovery in this sector, with 81 maquiladoras in operation in 2004 (Austin, et al. 2004). Additional significant areas of economic activity include the government and education sectors.

YUMA-SAN LUIS RÍO COLORADO

The Yuma-SLRC region comprises several different communities, not all of which border continuously with each other. They are commonly separated by agricultural areas. Yuma, Arizona, at an elevation of only about 150 feet above sea level, has an ecosystem quite different from Douglas-Agua Prieta or Ambos Nogales. Summertime highs typically peak at 110°F, and winter lows are typically around 45°F to 50°F, with freezes rarely occurring. The Western Regional Climate Center at the Desert Research Institute reports annual average precipitation in Yuma to be 3.33 inches, based on data spanning the years 1893 to 1974 (Western Regional Climate Center No Date), making Yuma considerably drier than Ambos Nogales and Douglas-Agua Prieta. Unlike Ambos Nogales and Douglas-Agua Prieta, the Yuma-SLRC area receives its precipitation almost exclusively during summer monsoons.

The Yuma-SLRC region is located in a very large, relatively flat valley, surrounded by low mountain ranges (or high hills) located a significant distance from the population centers. Although air quality in the border sister-city pair of San Luis, Arizona, and San Luis Río Colorado, Sonora, is quite similar due to the two cities' proximity, air quality in other communities in this region likely varies somewhat, although the communities are still mutually influenced. The nature and reasons for this variability have yet to be determined. Due to violations of the air quality standards for PM in the late 1980s and early 1990s, EPA designated the Yuma Nonattainment Area, which includes a portion of western Yuma County with the cities of Yuma and Somerton and portions of the Yuma Proving Ground. Primary sources of PM emissions in the Yuma Nonattainment Area are, in descending order of contribution, windblown dust, unpaved roads, road construction, agricultural till-

ing, re-entrained dust from paved road construction, and agricultural and prescribed burning. Emissions from brick kilns are also a concern in the area closest to the international border.

According to INEGI, the population of SLRC in 2000 was 145,006 (Gobierno del Estado de Sonora No Date-c), although many local residents believe the actual population to be somewhat higher—perhaps as high as 180,000. According to ADES, the population of Yuma was 86,070 in 2004, and two nearby communities (San Luis and Somerton) had an additional 30,035 people (Table 1).

Thus, although the adjacent sister-city communities of San Luis and SLRC have a similar population balance to those of Ambos Nogales and Douglas-Agua Prieta, the total population on the Arizona side of the entire Yuma-SLRC region is much larger than in the other regions. It should be noted that there is daily and seasonal binational population movement in the Yuma area, as agricultural workers living in SLRC travel to work legally in the agricultural areas of Yuma County. The degree to which this day-time influx influences the total population, however, is not known to the authors.

The most important economic activities in Yuma-SLRC are in the agricultural, customs brokers, maquiladora, tourism, and government/school sectors. Presumably, the maquiladora sector has suffered a downturn in recent years in SLRC similar to that seen in Nogales, Sonora, and Agua Prieta. SLRC had 42 maquiladoras in 2001, but as of 2002, *Twin Plant News* (the source of the data reported in Austin, et al. 2004) no longer separated the numbers of maquiladoras in SLRC from totals for the rest of Sonora, outside of Nogales and Agua Prieta.

OTHER PARTS OF THE ARIZONA-SONORA BORDER

Most of this chapter will focus on the three areas described above. There are, however, several more geographical areas between those three along the Arizona-Sonora border that deserve mention either with respect to air quality or to give a better sense of the entire region. Moving from east to west, the first of these is the sister-city pair of Ambos Naco—the unincorporated community of Naco,

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Arizona, and the small municipality of Naco, Sonora, which are located approximately 20 miles west of Douglas-Agua Prieta and a 15-minute drive south of Bisbee, Arizona. The population of Naco, Arizona, is approximately 1,000 and the population of Naco, Sonora, is about 7,000.

Although PM has not been deemed a problem in Ambos Naco at levels warranting the designation of a nonattainment area, the area was challenged for many years by sporadic fires at the municipal dump in Naco, Sonora. The smoke from these fires was occasionally thick enough to cause the Bureau of Customs and Border Protection to close down the port of entry, an action that is quite disruptive to the local community as well as travelers throughout the surrounding region. After a few years of responding to these events and discussing them with officials and residents on both sides of the border, the Arizona Department of Environmental Quality (ADEQ) determined that many of the fires were likely caused by the disposal of ashes from residential cooking and heating that were not completely extinguished. Once in the dump, these ashes were causing combustible materials also present in the dump to catch fire. During the winter of 2003–2004, ADEQ distributed copies of a simple flier encouraging residents to ensure their ashes were completely extinguished before disposing of them in the dump. Municipal authorities in Naco, Sonora, distributed copies to all residents through door-to-door visits. Since that outreach was conducted there have not been any more fires at the dump. In the meantime, efforts are underway to upgrade waste management facilities in Naco, Sonora.

The Coronado National Forest, comprising five ranger districts, covers 1.78 million acres of land, mostly in southeastern Arizona but with a small portion in southwestern New Mexico. Two major portions of the Coronado National Forest are located directly along the Arizona-Sonora border, one between Naco-Sierra Vista and Nogales and the other to the west of Nogales. As with other forest areas throughout the state of Arizona, these areas are susceptible to wildfires, and controlled burns have occasionally been used in these areas with the hope of preventing larger, uncontrolled wildfires.

The Chiricahua Wilderness Area and the Chiricahua National Monument Wilderness Area are designated Class I Areas under the Clean Air Act. Ozone is regularly monitored at a station located at

the Chiricahua National Monument. Although the National Monument is outside the 100-km border zone, it is close enough that air quality there could reasonably be used as a background reference site in comparison to air quality in Douglas-Agua Prieta and Ambos Nogales, were ozone to be monitored in those communities in the future.

Continuing toward the west, the next area of significant importance along the Arizona-Sonora border is the Tohono O'odham Nation (the formal name on the U.S. side), with a U.S. population of approximately 24,000 and another approximately 1,400 members in Mexico. Comprising a total area in Arizona about the same size as the state of Connecticut, the Tohono O'odham Nation has a 75-mile border with Sonora. A substantial portion of the nation is located within the 100-km border region and there are a number of Tohono O'odham communities in Sonora, as the nation's traditional lands are bisected by the international boundary. Although no air quality monitoring has been conducted within the Tohono O'odham Nation, tribal leaders have raised concerns about the possible air quality impacts of wood burning, garbage burning, unpaved roads, and agricultural practices.

Bordering the Tohono O'odham Nation on the west, the Organ Pipe Cactus National Monument also shares a long (approximately 30 miles) border with Mexico. ADEQ maintains a PM₁₀ (particulate matter measuring 10 microns or less in diameter) sampler at the monument, as well as a nephelometer measuring visibility.

Continuing west, the Cabeza Prieta National Wildlife Refuge borders on both Sonora and the Organ Pipe Cactus National Monument. Next, the Barry M. Goldwater Air Force Range borders both Sonora and the Cabeza Prieta National Wildlife Refuge.

In the stretch of the border region from the eastern edge of the Arizona portion of the Coronado National Forest to the western edge of the Barry M. Goldwater Air Force Range (located about 15 miles east of San Luis, Arizona)—representing 280 miles of the total Arizona-Sonora border, which measures 360 miles—there is very little non-federal, non-tribal land.

CONTRASTS WITH OTHER REGIONS

The previous section demonstrates that the Arizona-Sonora border region may be characterized as almost entirely rural, with three concentrated areas of urban development where most of the air quality concerns arise. Although on the surface this general characterization (urban areas of concern separated by large rural areas) may seem similar to the characterizations of other regions along the U.S.-Mexican border, there are some important differences. Also, while these three areas share some characteristics in common, they also have several differences among them that will become clearer in later sections of this chapter.

The populations, levels of economic activity, and total quantities of inventoried emissions from various sources in other parts of the U.S.-Mexican border region are generally significantly larger than those found along the Arizona-Sonora border. This difference of scale has several consequences, many of which will be explored later in this chapter. For example, the financial resources made available to address air quality issues along the Arizona-Sonora border are considerably less than in other regions. The institutional capacity to address air quality issues is also less, whether measured by the size of local governments, the number of colleges and universities, the number of non-governmental and community-based organizations, or the number of businesses and their ability to benefit directly from participation in air quality improvement activities. Because federal air environmental activities along the U.S.-Mexican border have focused on the larger metropolitan areas such as San Diego, California-Tijuana, Baja California, and Paso del Norte (El Paso, Texas; Doña Ana County, New Mexico; and Ciudad Juárez, Chihuahua), air quality issues important to Arizona-Sonora communities may struggle to receive national-level policy attention if they are not accorded the same level of importance as other regions of the border.

Nevertheless, working in the Arizona-Sonora border region may also have its advantages. The second type of difference between the Arizona-Sonora border region and other parts of the U.S.-Mexican border relates to the nature of binational cooperative efforts. At the formal level of state-to-state cooperation—an important aspect of

the model set up by Border 2012—Arizona and Sonora have a decades-long history of collaborative efforts. The Paso del Norte region, with 10 years of collaboration on air quality, is the only other area that approaches the maturity of the Arizona-Sonora relationship.

Much of this success has been accomplished through the Arizona-Mexico Commission and its sister organization, the Comisión Sonora-Arizona. The Environment Committees of these organizations have adopted many recommendations and action items over the years relating to air quality along the Arizona-Sonora border. It is often the approval of these commissions, which are chaired by the governor of each state, that allows binational cooperation on air quality (and other environmental matters) to proceed without the need for the protracted negotiations involved in establishing federal treaties. This state-to-state cooperation has allowed ADEQ, with support and approval from the Secretaría de Infraestructura Urbana y Ecología (SIUE), to carry out important efforts like conducting outreach in Sonora, working directly with Sonoran municipalities to establish air quality monitoring stations, and providing direct technical assistance to Sonoran municipalities in obtaining Border Environment Cooperation Commission (BECC) certification of air quality projects.

As a result of the direct role of the two state governments in border air quality efforts, it may be easier in this region to transfer successes and lessons learned from one community to another. In addition, the much smaller total population and economic growth pressures in a community like Douglas-Agua Prieta, compared to other areas, may make it easier for these cities to succeed in the cooperative air quality improvement efforts described below.

In short, the Arizona-Sonora border region is a rural region with small urbanized areas trying to succeed in a binational program of much larger, more urbanized scale. This contrast has both its challenges and its advantages.

BACKGROUND ON AIR QUALITY

Monitoring Results and Compliance Status

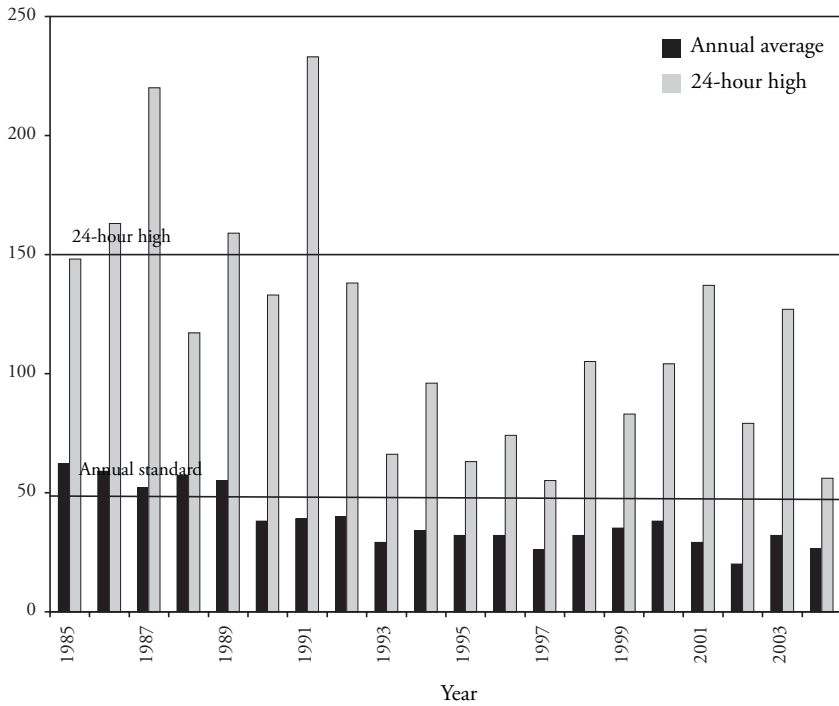
This section summarizes the results of ambient air quality monitoring in the Arizona-Sonora region and shows how those results relate to the National Ambient Air Quality Standards (NAAQS) in the United States and the similar set of Normas Oficiales Mexicanas (NOM) established by Mexico. These standards are listed in Table A near the beginning of this volume. As well, Table B explains the criteria applied to the U.S. standards in order to determine attainment or nonattainment in specific geographic areas in the United States.

DOUGLAS-AGUA PRIETA

In Douglas, monitoring of PM_{10} concentrations began in 1985 and monitoring of $PM_{2.5}$ ($PM_{2.5}$ microns or less in diameter) began in 1993. In Agua Prieta, monitoring of both PM_{10} and $PM_{2.5}$ began in 1999. Figures 1 and 2 show data trends for Douglas for PM_{10} and $PM_{2.5}$, respectively. Similarly, Figures 3 and 4 show data trends for PM_{10} and $PM_{2.5}$ in Agua Prieta. In the figures for $PM_{2.5}$, the maximum 24-hour average is shown. The federal standard is expressed as the 98th percentile value, but because the sampling frequency is every sixth day, yielding about 60 samples per year, the maximum value and the 98th percentile value are the same.

Binational Air Quality Management

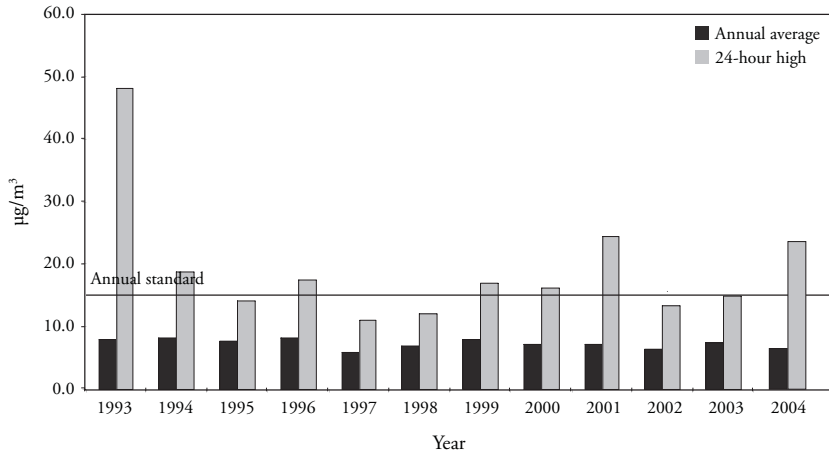
Figure 1. Annual Average and Annual 24-Hour High for PM₁₀ in Douglas, Arizona, 1993–2003



Source: Arizona Department of Environmental Quality

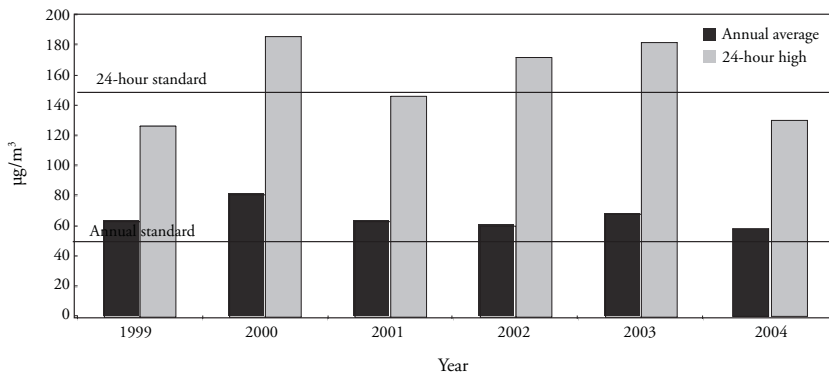
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Figure 2. Annual Average and Annual 24-Hour High for PM_{2.5} in Douglas, Arizona, 1993–2003



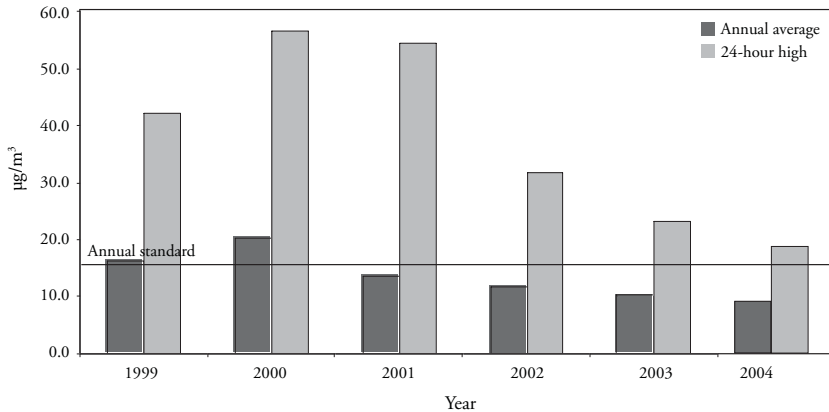
Source: Arizona Department of Environmental Quality

Figure 3. Annual Average and Annual 24-Hour High for PM₁₀ in Agua Prieta, Sonora, 1999–2003



Source: Arizona Department of Environmental Quality

Figure 4. Annual Average and Annual 24-Hour High for PM_{2.5} in Agua Prieta, Sonora, 1999–2003



Source: Arizona Department of Environmental Quality

These graphs show several interesting things. First, Douglas violated the annual standard from 1985 through 1989 and the 24-hour standard in four of the seven years from 1985 through 1991. Since that time, Douglas has consistently met the U.S. air quality standards. Annual averages for concentrations of both PM₁₀ and PM_{2.5} have remained relatively constant since the early 1990s. The highest 24-hour reading for PM_{2.5} has also remained relatively constant during this period, except for two outlying values recorded in 1993 and 2001—both of which were well within the compliance range. While the highest 24-hour readings for PM₁₀ may show a somewhat upward trend during the monitoring period, these values are still within the compliance range (it is impossible to explain this apparent upward trend without conducting a significantly more detailed evaluation of all data collected).

The data for Agua Prieta show PM₁₀ concentrations above the applicable Mexican air quality standards (Mexican Allowable Limits) almost every year, with both the annual average and the highest 24-hour reading remaining relatively constant during the monitoring period. Mexico did not have PM_{2.5} standards when this analysis was originally prepared (such standards were established in September 2005 and are included in Table A at the beginning of this mono-

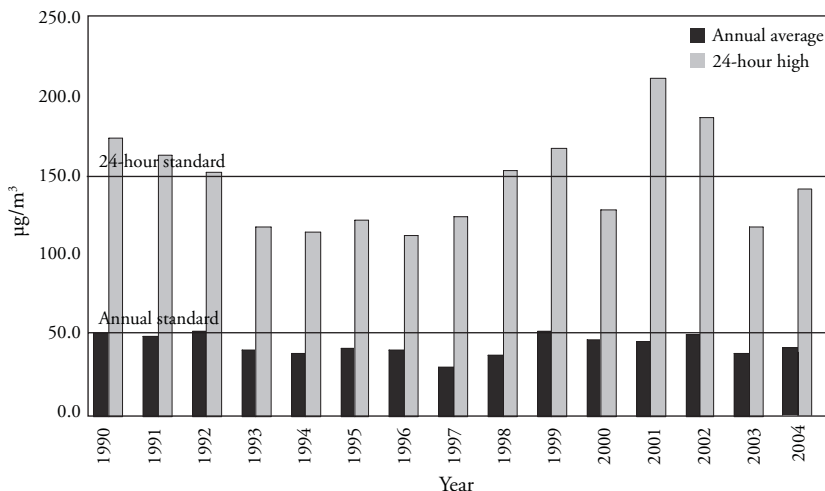
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graph), but the $PM_{2.5}$ data show Agua Prieta would have complied with the U.S. 24-hour standard during the entire monitoring period. Although $PM_{2.5}$ annual average values would have violated the U.S. standard at the beginning of this monitoring period, the annual averages in more recent years would comply with the U.S. standard. Both annual average and 24-hour values show a downward trend in Agua Prieta.

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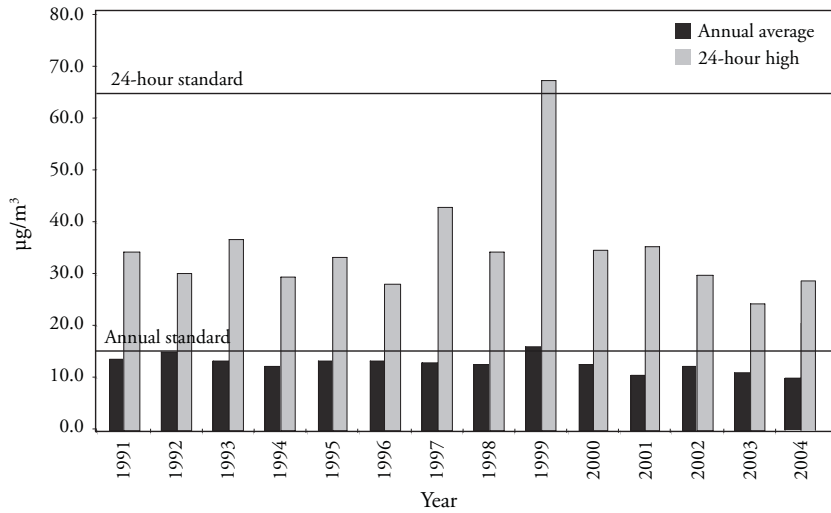
PM data have been collected in Nogales, Arizona, and Nogales, Sonora, since 1990 and 1995, respectively. Figures 5 and 6 show data trends for Nogales, Arizona, for PM_{10} and $PM_{2.5}$, respectively. Figures 7 and 8 show data trends for PM_{10} and $PM_{2.5}$ in Nogales, Sonora.

Figure 5. Annual Average and Annual 24-Hour High for PM_{10} in Nogales, Arizona, 1990–2003



Source: Arizona Department of Environmental Quality

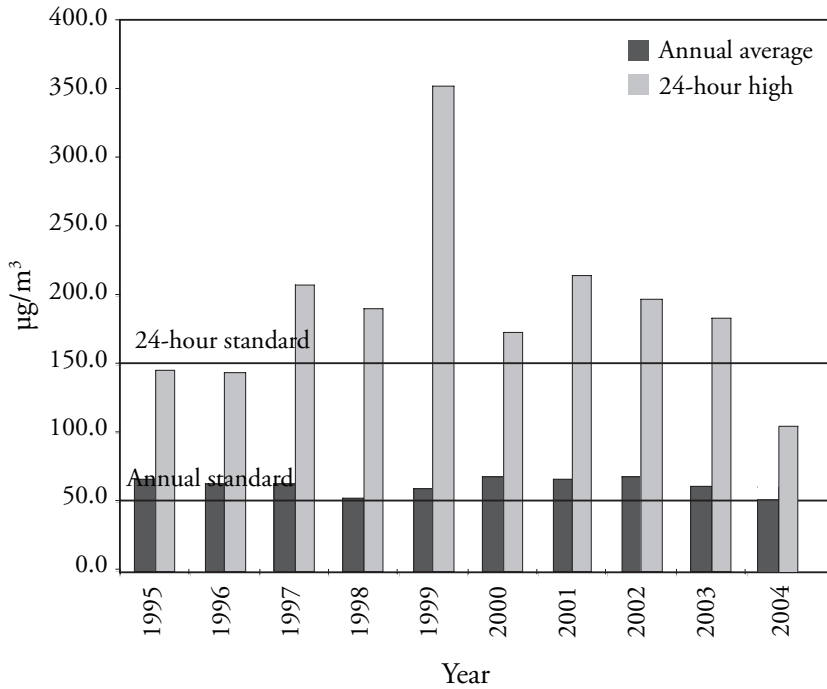
Figure 6. Annual Average and Annual 24-Hour High for PM_{2.5} in Nogales, Arizona, 1991–2003



Source: Arizona Department of Environmental Quality

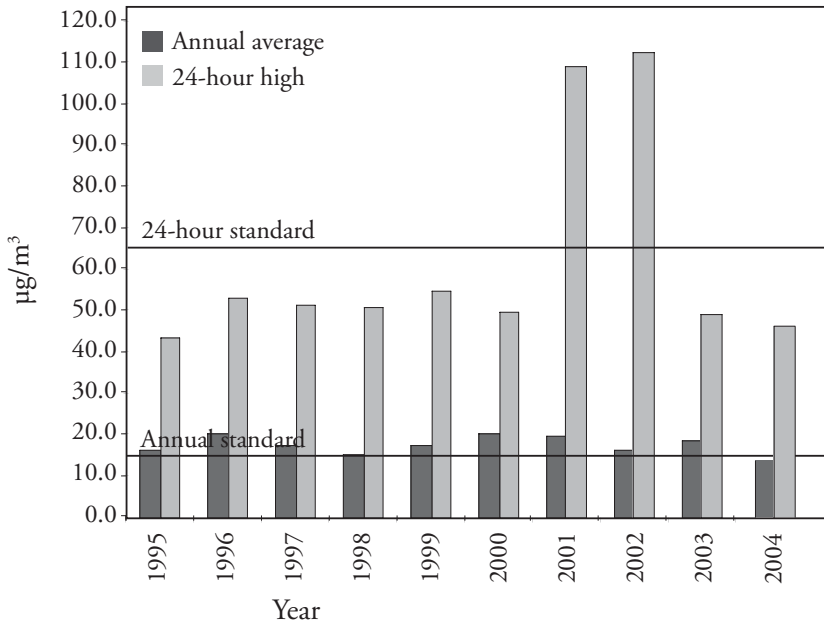
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Figure 7. Annual Average and Annual 24-Hour High for PM₁₀ in Nogales, Sonora, 1995–2003



Source: Arizona Department of Environmental Quality

Figure 8. Annual Average and Annual 24-Hour High for PM_{2.5} in Nogales, Sonora, 1995–2003



Source: Arizona Department of Environmental Quality

In reviewing the data in these graphs, the first point to note is that Nogales, Arizona, has not violated the annual PM₁₀ standard since the early 1990s. However, PM₁₀ annual average levels have shown an upward trend since 1996, with the exception of 2000 and 2003. PM₁₀ annual averages in a few individual years exceeded the standard, but compliance is determined by three-year running averages and Nogales has never been in violation, although in one period it came very close. On the other hand, the 24-hour PM₁₀ standard has been violated consistently since 1998. Although there is variation in the data, the yearly maximum 24-hour PM₁₀ concentrations increased from 1996 to 2001, and then began to decrease.

PM_{2.5} levels in Nogales, Arizona, have generally complied with the annual and 24-hour standards, although there have been occasional exceedances. Both annual average and 24-hour levels have

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consistently fluctuated within a steady range, although the 98th percentile 24-hour level for 1999 was well above all other years, as was the annual average for 2003.

With regard to PM_{10} concentrations in Nogales, Sonora, both the 24-hour concentrations and the annual averages are generally slightly higher than those in Nogales, Arizona, with the Mexican Allowable Limits regularly being violated.

Over time, these levels have fluctuated within a fairly constant range. $PM_{2.5}$ levels in Nogales, Sonora, have also generally fluctuated within a fairly constant range, and the annual averages would consistently violate the U.S. standard, although the 98th percentile 24-hour values would generally comply with the U.S. standard. The 98th percentile 24-hour values for 2001 and 2002 show a notable exception, significantly exceeding the U.S. standard.

There are various possible explanations for these data trends. First, in the mid-1990s both the annual average and 24-hour PM_{10} concentrations were down in Nogales, Arizona, compared to earlier years when violations led to the designation of the nonattainment area. This reduction may be a result of actions taken on the basis of the State Implementation Plan (SIP) for the Nogales Nonattainment Area, adopted in 1993. They may also reflect the closure of the old landfill in Nogales, Sonora, and the cessation of garbage-burning activities that used to occur there regularly. However, once these actions had their effect, perhaps the continuing growth in the population of Ambos Nogales once again contributed to increased emissions levels from more unpaved roads, more cars, more soil erosion, and more wood and garbage burning. In addition, crossborder commerce has also grown, which leads to more truck and passenger vehicle traffic. Finally, most of the PM_{10} 24-hour highest values have occurred during the winter months, which may reflect a combination of a higher incidence of wood-burning for home heating and atmospheric inversion layers that trap emissions in the Ambos Nogales valley.

For several reasons, PM is the only category under NAAQS regularly monitored in Ambos Nogales. A binational ADEQ-Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) study (published in 1999) monitored lead concentrations but did not find any problem. Sulfur dioxide is presumed not to be an issue because there

are no smelters or other important sources of sulfur dioxide emissions in Ambos Nogales. The other criteria pollutants—ozone, nitrogen oxides (NO_x), and carbon monoxide—have not been monitored in Ambos Nogales for more than nine years, and no local monitoring stations for any of these pollutants exist. ADEQ is currently working to install a monitor capable of measuring these three pollutants in Ambos Nogales' air to make a preliminary determination of whether there may potentially be a nonattainment issue and whether more detailed monitoring is warranted.

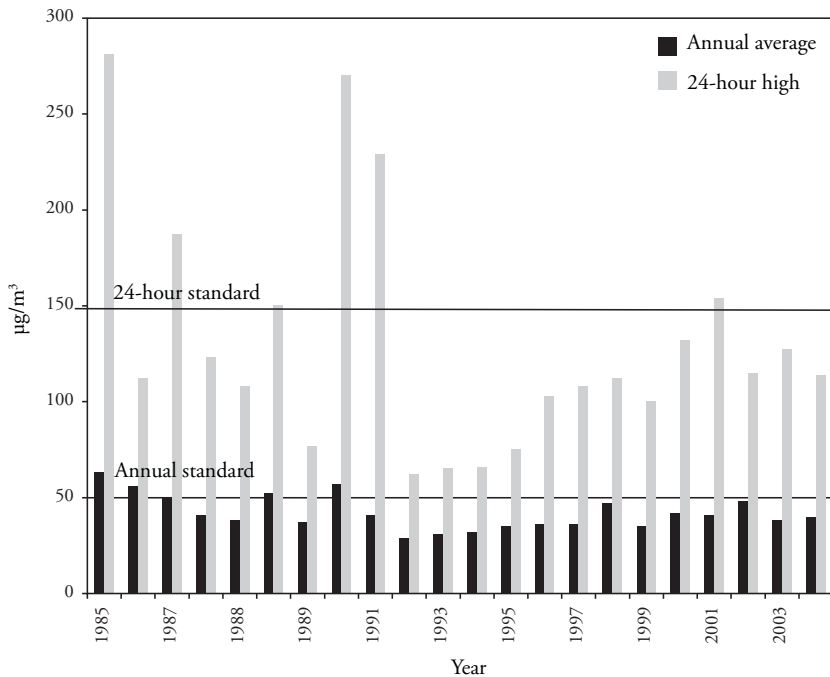
YUMA-SLRC

Through 2005, air pollution monitoring efforts in this sister-city area were limited to Yuma County. Long-term trends in that county have been assessed for both particulates and ozone. The binational air toxics monitoring program began in February 2006 with the installation of sites in Yuma and SLRC. This section presents the Yuma ambient air quality record.

Monitoring for PM_{10} began in Yuma in 1985 and has continued through the present. The monitoring data presented in Figure 9 show exceedances of both the annual and 24-hour standards occurred through the early 1990s, but since then the standards have been met. On August 18, 2002, a 24-hour average concentration of 170 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) was recorded. Subsequent analysis showed the extremely windy and dry conditions of that date qualified it as a “natural exceptional event.” Through a Natural Events Action Plan (NEAP), Somerton, the City of Yuma, and Yuma County have agreed to apply the Best Available Control Measures (BACM) to the contributing PM_{10} emission sources in return for having the concentration removed from the compliance record.

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Figure 9. Annual Average and Annual 24-Hour High for PM₁₀ in Yuma, Arizona, 1985–2004



Source: Arizona Department of Environmental Quality

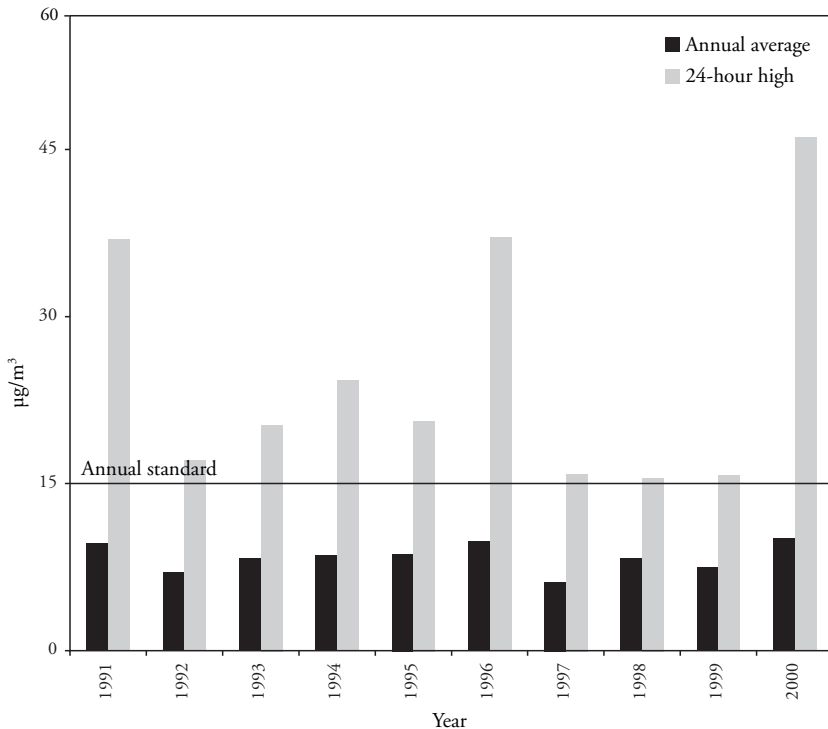
The overall PM₁₀ trends depict elevated, above-standard concentrations in the mid-1980s and early 1990s, followed by a long period of uninterrupted compliance with the standards. Because of the PM₁₀ violations in the 1980s, the western area of Yuma County was designated a moderate PM₁₀ nonattainment area by the 1990 Clean Air Act Amendments. ADEQ completed a SIP for the Yuma Moderate PM₁₀ Nonattainment Area in 1991 and updated the plan in 1994. As a result of several years of measured attainment with the air quality standards for PM₁₀, ADEQ began working with the stakeholders in July 2001 to develop a request to EPA to redesignate Yuma from non-attainment to attainment. This request requires a “maintenance plan” that demonstrates that the control measures in

Binational Air Quality Management

effect will assure compliance with the standards for at least 10 years. It also requires the most recent three years of monitoring data meet the standards.

PM_{2.5} concentrations, monitored with dichotomous samplers throughout the 1990s (Figure 10), were within the ambient air quality standards in Yuma. Only three 24-hour average samples exceeded 30 µg/m³ and none exceeded 50 µg/m³, within the standard of 65 µg/m³. Annual averages ranged from 6 µg/m³ to 10 µg/m³, well within the standard of 15 µg/m³.

Figure 10. Annual Average and Annual 24-Hour High for PM₁₀ in Yuma, Arizona, 1991–2000

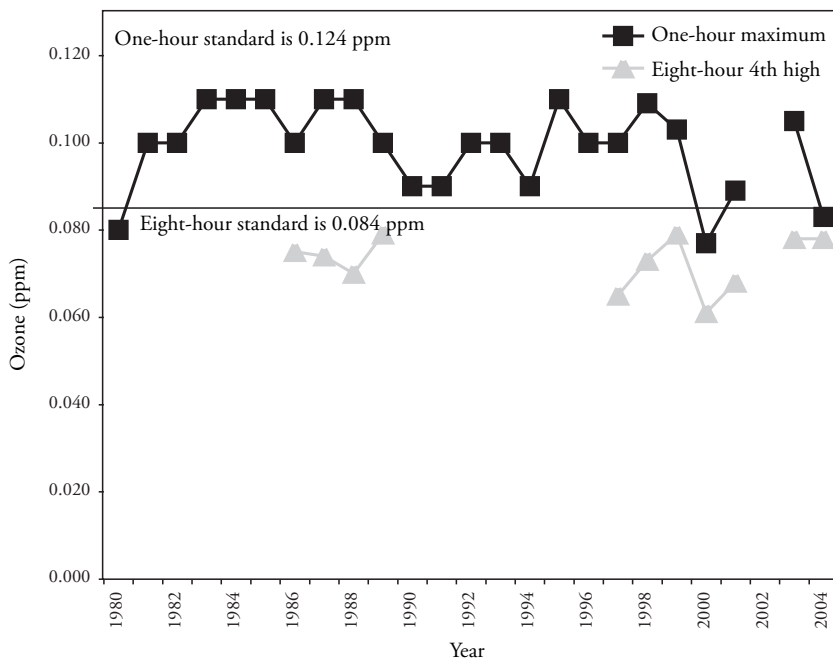


Source: Arizona Department of Environmental Quality

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Monitoring for ozone began in Yuma in 1980. Maximum one-hour and the fourth-highest eight-hour concentrations have been well within the ambient standards. Figure 11 shows that these values have fluctuated somewhat but have remained steady with neither an upward nor downward trend in the 25-year period. In addition to ozone, monitoring in Yuma began for NO_x , an ozone precursor, in 2003.

Figure 11. Maximum One-hour and Fourth-Highest Eight-hour Concentrations of Ozone in Yuma, Arizona, 1980–2004



Source: Arizona Department of Environmental Quality

BINATIONAL STUDY METHODS AND RESULTS

Binational air quality monitoring and modeling efforts along the Arizona-Sonora border began in 1995 with the installation of three monitoring stations in Ambos Nogales. These three new sites had been preceded by the first monitoring site at the Nogales, Arizona, post office in 1990. Together, these four stations comprised a binational network that was created to address air quality concerns through a five-year, comprehensive study funded by EPA. The Ambos Nogales study was the first of its kind anywhere along the U.S.-Mexican border and set the stage for similar cooperative projects to follow in other border sister cities.

A second binational air quality study was started in Douglas, Arizona, and Agua Prieta, Sonora, in 1999, drawing from the experience gathered through the Ambos Nogales effort. Once the data collection phase of each of these binational studies was completed, local air quality monitoring efforts were scaled back to focus on PM, with one monitoring station in each of the four communities. These ongoing monitoring efforts allow the evaluations of trends over time, as discussed above. A third binational study, the largest of its kind anywhere along the U.S.-Mexican border, is in its initial stages in the Yuma-SLRC region. This section describes the status and results (where available) of these binational studies.

STUDY PHASES

The Ambos Nogales study was prompted by community concerns about the high incidence of certain ailments and illnesses (such as asthma, lupus, and multiple myeloma) in the sister communities. These health conditions were thought to be attributable, at least in part, to poor air quality. As mentioned above, the Ambos Nogales study began with one year of binational air quality monitoring at six stations (three on each side of the border) that included meteorological parameters (wind speed and wind direction), PM₁₀ and PM_{2.5}, aldehydes, volatile organic compounds (VOCs, including several hazardous air pollutants, or HAPs, such as aldehydes), and semi-volatile organic compounds (SVOCs). The study area was approximately 5 km from east to west and 10 km from north to

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south. In addition to the sampling/monitoring effort, the Ambos Nogales project included the development of an air emissions inventory, atmospheric simulation models, and a human health risk assessment for both sides of the border. The study was published in 1999 (ADEQ 1999).

The Douglas-Agua Prieta study began with air quality monitoring at four stations (two on each side of the border), covering a study area of approximately 32 km from east to west and 40 km from north to south. In addition to the components and parameters used in the Ambos Nogales study, the Douglas-Agua Prieta effort included carbon monoxide and NO_x monitoring, the use of a wind profiler to better understand wind patterns at the different levels of the atmosphere, time-lapse photography, and the use of portable PM₁₀ monitors, among other improvements. An emissions inventory of the Douglas-Agua Prieta area was completed in summer 2002. Since then, efforts have focused on air quality modeling in order to establish the exposures that local residents likely experience; this modeling is based on data gathered during the air quality monitoring and emissions inventory phases. As in the case of Ambos Nogales, this binational study will conclude with a public health risk assessment to determine the community impacts resulting from the modeled likely exposures.

As mentioned above, the Yuma-SLRC binational study, often referred to as the Western Arizona Sonora Border Air Quality Study, will be the largest of its kind ever undertaken along the U.S.-Mexican border. The study area is approximately 60 km from north to south and 80 km from east to west. It covers parts of three states (Arizona, Sonora, and Baja California), several towns and municipalities, and three Native American tribal nations. As the study develops, there may be a need to explore the possible influence of emissions from another major binational metropolitan area—Mexicali-Calexico—on air quality in the Yuma-SLRC area. Clearly, this study will require unprecedented levels of coordination. At this time, meteorological data is being gathered at several locations on both sides of the border to determine the more stable locations to collect air samples. Future study phases will likely follow the pattern

established in the Ambos Nogales and Douglas-Agua Prieta binational studies, including air quality monitoring, the development of an emissions inventory, and a public health risk assessment.

PRIMARY CONTAMINANT SOURCES

Prior to the commencement of the Ambos Nogales binational study, the old municipal dump in Nogales, Sonora, was seen by community residents as the root of their air quality-related problems. Open burning would occur regularly at the dump, largely driven by cottage-industry waste recovery efforts such as burning the plastic coating off copper wire in order to recover the valuable copper. The municipal dump was closed in 1995 and replaced with a modern landfill in the southern end of the city, which has not presented any garbage burning-related problems since it was opened.

The Ambos Nogales binational study found that PM_{10} is the primary health risk factor in the Ambos Nogales air. Unpaved road dust is the main source, and approximately 85% of the PM_{10} in Nogales, Arizona, was found to originate in Nogales, Sonora. In addition, it was determined that vehicular emissions are the leading source of HAPs.

Based on this study and knowledge of local conditions, local efforts to improve air quality now focus on five primary PM_{10} emissions sources:

- Residential emissions (from the burning of wood and garbage at or near people's homes)
- Soil erosion (which deposits on paved and unpaved roads, raising their emissions levels)
- Unpaved traffic areas (roads and parking lots)
- Traffic congestion (especially at the ports of entry, in relation to the train route, and at under-designed intersections)
- Vehicle emissions (from passenger vehicles as well as commercial trucks), which are also a source of HAPs

The phases of the Douglas-Agua Prieta study completed to date show emissions from unpaved roads are the largest contributors of PM. Wind erosion of crustal materials from such surfaces as vacant lots and other disturbed areas is also a significant source of PM in

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the area. This study also paid special attention to a few emissions sources perceived as possible problems by local residents, such as brick kilns and tire dragging (which the Border Patrol conducts to smooth the dirt on unpaved roads near the border as part of its effort to track undocumented entry into the United States). The study found emissions from burning fuels at brick kilns do indeed have a measurable effect on local air quality. The tire dragging accounted for only 0.8% of the on-road mobile PM₁₀ emissions. On-road mobile sources account for approximately 91% of the overall HAP emissions and 87% of the total carbon monoxide emissions in the study domain. This source category is also the largest contributor of NO_x emissions in the study domain.

Oxides of sulfur (SO_x) in this area are predominantly emitted by the Mexicana de Cobre lime plant in Agua Prieta and the lime plant located in Paul Spur, west of Douglas. The former plant has been in continual operation in the last 20 years, while the latter has been shut down for several years. SO_x has not been measured in Douglas since the close of the Phelps-Dodge smelter in 1987.

An additional source of SO_x emissions is the Union Fenosa power plant south of Agua Prieta, which began operations in 2003. The Comisión Federal de Electricidad (Mexican Federal Electricity Commission) recently announced that this power plant will be expanded from 350 megawatts (MW) to 1,450 MW by 2008, with an increase in SO_x emissions from 33 tons to 133 tons per year. The 1,100 MW of additional capacity will comprise a gas-fired combined cycle plant. Also, a 30-MW array of solar photovoltaic panels will be installed nearby on 50 hectares of land.

As neither the air quality monitoring for criteria pollutants and HAPs nor the emissions inventory have commenced for the Yuma-SLRC binational study, it is premature to draw firm conclusions about the primary emission sources impacting air quality in this area. In general, however, it is expected that unpaved roads, vehicle emissions, traffic congestion, soil erosion, and residential garbage burning will likely be shown to play important roles, as they do in Ambos Nogales and Douglas-Agua Prieta.

In addition, several specific issues have been identified for attention in Yuma-SLRC as the binational study progresses. These include agricultural burns, brick kilns, agricultural tilling practices,

garbage burning at the municipal dump, unpaved roads, and the role SLRC plays in connecting commercial traffic from Baja California to the rest of Mexico. Some preliminary information about these sources is available. Approximately 98% of all agricultural land in the area is planted in wheat; these fields are typically burned from June through September. The remaining 2% is planted almost entirely in asparagus, and these fields are typically burned during March and April.

Combustion at brick kilns and the municipal dump in SLRC generate problematic emissions. There are an estimated 130 brick kilns in SLRC and another 100 in the surrounding areas. Garbage burning at the dump still occurs, unlike in Douglas-Agua Prieta and Ambos Nogales, although the frequency and size of these burns are unknown. Additionally, it is estimated that approximately 83% of all roads in SLRC are unpaved.

Finally, there is a great deal of both domestic and crossborder heavy-duty diesel commercial truck traffic through the Yuma-SLRC area. This traffic occurs partly because Mexican Route 2 provides the only land transportation between Baja California and the rest of Mexico. Another important factor is truckers importing goods to the United States in the Yuma area have various choices of ports of entry—those in San Luis, and those en route to and in Calexico-Mexicali, which is not far away. It is unclear how these choices affect the number of trucks waiting in line to cross the border in San Luis.

Another factor that will need to be taken into account during the binational study and that differentiates Yuma-SLRC from Ambos Nogales and Douglas-Agua Prieta is the fact that soils throughout the Yuma-SLRC area appear to be much finer grained than soils in other parts of the Arizona-Sonora border. This difference is likely due to the long-term geological influence of the Colorado River.

HEALTH IMPACTS

Ambos Nogales Health Risk Assessment

In the binational study for Ambos Nogales (ADEQ 1999), adverse health effects were evaluated for two types of "receptor" individuals that were selected as representative examples of the general population on each side of the border. The first type, a reasonable maximal exposure (RME) receptor, is a designation for people who have relatively high exposures to the studied HAPs—essentially a "worst case" scenario. The RME applies to individuals who live or work near major sources of pollution and who may, therefore, be exposed to higher concentrations than the general population. Secondly, a central tendency case (CTC) receptor identifies people who have average exposures. Studying these two cases provides a realistic range of exposures and the associated human health risks.

Risks due to PM_{10} exposure were estimated by using human health statistics derived from epidemiological studies and applying them to the concentrations to which the RME and CTC receptors are expected to be exposed. The RME and CTC exposure areas are the same for HAPs and PM_{10} . The percentage increase in cases of health problems on an average daily basis related to PM_{10} pollution was estimated. In addition, the expected increase in numbers of premature respiratory and cardiovascular deaths among elderly people who already have lung or heart problems was estimated. This is the percentage increase in the number of deaths per year per thousand people. Both of these kinds of percentage increases in health effects are those percentages associated with an increase in PM_{10} concentrations of $10 \mu\text{g}/\text{m}^3$. These estimates are provided in Table 2.

Table 2. Estimated Percentage Increase in Health Effect Cases and Estimated Increase in Absolute Numbers of Premature Deaths in Ambos Nogales Caused by Each Increment of 10 $\mu\text{g}/\text{m}^3$ of PM_{10}

Health Effect	Percentage Increase in Incidence, by Location and Exposure Scenario			
	Nogales, Arizona		Nogales, Sonora	
	CTC ¹	RME ²	CTC ¹	RME ²
Hospital admissions	2	3	2	4
Asthma episodes	8	13	8	14
Lower respiratory illness	8	13	8	14
Coughs	3	5	3	6
Premature respiratory deaths	2	3	16	28
Premature cardiovascular deaths	3	5	28	44

¹ CTC = Central tendency case (individuals with average exposure to the studied hazardous air pollutants)

² RME = Reasonal maximal exposure (individuals with high exposure to the studied hazardous air pollutants)

Source: Arizona Department of Environmental Quality

The increased percentages of health problem cases resulting from PM were generally the same in Nogales, Arizona, and Nogales, Sonora, because residents of both communities are exposed to similar concentrations of PM. The absolute numbers of premature deaths that may be attributed to PM exposure are higher in Nogales, Sonora, because the population is larger—by as much as tenfold or more—than in Nogales, Arizona.

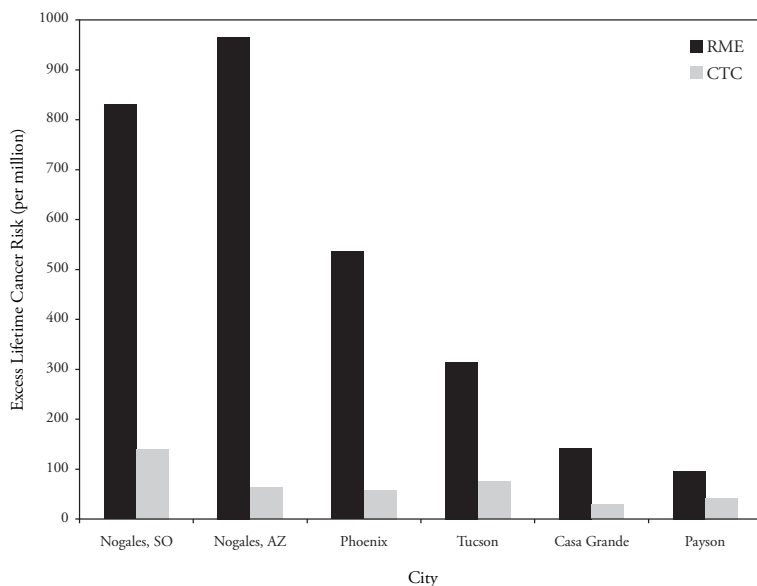
These health risks from PM_{10} , as well as the risks from HAPs, can be put into the context of the health risks determined in the Arizona HAPs project for four Arizona cities and towns. Results from the Arizona HAPs study and the Ambos Nogales study show risks from PM_{10} exposure in Ambos Nogales were generally somewhat lower than in Phoenix, while somewhat higher than in Tucson.

The study also determined the cancer and non-cancer health risk from HAPs. It estimated the excess lifetime cancer risks for the CTC and RME exposure scenarios to be 141 in 1 million and 830 in 1

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million, respectively, in Nogales, Arizona. Similarly, the study estimated the excess lifetime cancer risks for the CTC and RME exposure scenarios to be 110 in 1 million and 996 in 1 million, respectively, in Nogales, Sonora. As in the case of PM, these risk rates from HAPs are similar in both communities because the concentrations to which residents are exposed are similar. The study compared these risk levels to risk levels calculated in a comparable manner for the cities of Phoenix, Tucson, Casa Grande, and Payson in Arizona (Figure 12). The study found the cancer risks for the RME exposure scenario in Ambos Nogales were higher than in the other four regions, while the cancer risks for the CTC exposure scenario in Ambos Nogales were about the same as in Phoenix but higher than in the other three regions.

Figure 12. Excess Lifetime Cancer Risks from Hazardous Air Pollutants in Nogales, Sonora, and Nogales, Phoenix, Tucson, Casa Grande, and Payson, Arizona

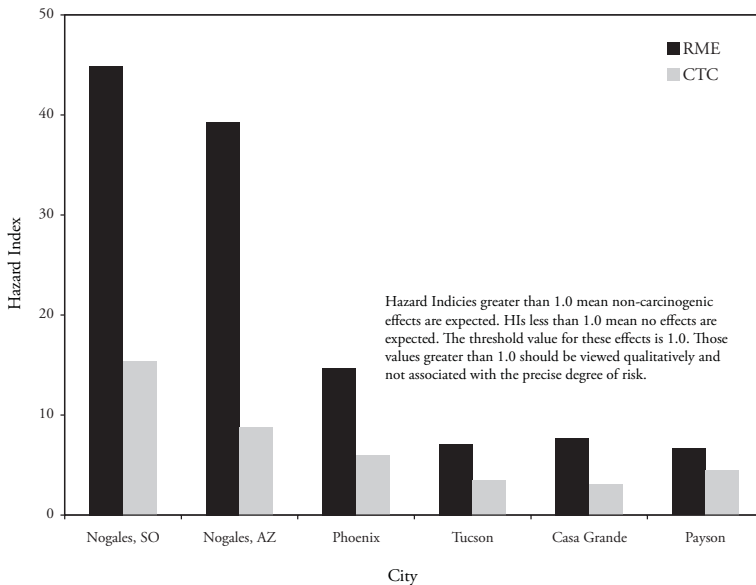


Note: RME = reasonable maximal exposure receptor; CTC = central tendency case receptor

Source: Arizona Department of Environmental Quality

HAPs produce both carcinogenic and non-carcinogenic risks, the latter of which are expressed in terms of a Hazard Index (HI). In this index, an HI of less than one for a given receptor indicates no adverse non-carcinogenic health effects are expected to occur from exposure to HAPs. For these non-carcinogenic effects, the HI value of 1.0 is considered a threshold value, above which adverse health effects are expected. Because of the inherent limitations in this type of toxicity evaluation, however, the magnitude of the HI cannot predict the precise probability or magnitude of the non-carcinogenic effects. For example, the Arizona and Sonora cites discussed in this chapter (Figure 13) have HIs ranging from three to 45. These statistics only mean that all the cities have airborne contaminants in concentrations that pose a non-carcinogenic risk, not that the city with the highest HI is 10 times riskier for its populace than another.

Figure 13. Hazard Indices from Hazardous Air Pollutants (HAPs) in Nogales, Sonora, and Nogales, Phoenix, Tucson, Casa Grande, and Payson, Arizona



Note: RME = reasonable maximal exposure receptor; CTC = central tendency case receptor

Source: Arizona Department of Environmental Quality

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The study found the total HI for non-cancer risks from the selected HAPs for young children, who are the most sensitive, were highest for the selected HAPs that have adverse respiratory effects. The study compared these HI for Ambos Nogales to HI calculated in a comparable manner for Phoenix, Tucson, Casa Grande, and Payson (Figure 13) and found the HI for the RME exposure scenario in Ambos Nogales are much higher than in any of the other four regions, while the HI for the CTC exposure scenario in Ambos Nogales are somewhat higher than in the other four regions. The overwhelmingly dominant cause of both cancer and non-cancer risks from HAPs on both sides of the border was found to be inhalation of organic compounds that result from the operation of motor vehicles.

STUDIES RELATED TO ASTHMA TRIGGERS ALONG THE ARIZONA-SONORA BORDER

Because the binational studies related to health risk assessments for Douglas-Agua Prieta and Yuma-SLRC have not yet commenced, it is difficult to provide reliable information about the health impacts local air quality conditions may be having on community residents. In the short term, an alternative approach would be to examine community-wide disease rates for various illnesses with some potential link to air quality, such as upper respiratory tract infections, asthma, lung cancer, emphysema, or premature death among elderly people with pre-existing heart or lung conditions.

Most of those data are not readily available, but one set of such data that is available comes from three parallel studies of asthma and air quality in Ambos Nogales, Douglas, and Somerton (near Yuma) among fifth-grade students. The time period for data collection in these studies ranged from 1996 (Ambos Nogales) to 2001 (Somerton). The limited ozone and carbon monoxide monitoring that was historically conducted in Ambos Nogales occurred as part of this study. Only one of these studies (Ambos Nogales) was binational, although the researchers hope to fill that gap in future research efforts.

The Ambos Nogales and Douglas studies found a positive correlation between increased respiratory symptoms and increased levels of PM pollution, as well as with temperature and exposure to second-hand smoke. On the other hand, the Somerton study found a positive correlation between increased respiratory symptoms and high or low temperatures, but did not find a correlation with pollution levels or exposure to second-hand smoke. The researchers have suggested that ambient monitoring data in that town may not have been adequate to support a robust statistical analysis. They also found evidence that asthma rates are likely under-diagnosed in all the studied communities. These studies are all summarized in a document titled “Research about Asthma Triggers in the Arizona-Sonora Border Region: A Review” (ADEQ 2004).

ADDITIONAL RESEARCH NEEDS

Based on the information presented above, as well as knowledge of the communities along the Arizona-Sonora border, additional research is needed in several areas. First, better information is needed about asthma rates and triggers, including air quality. This need is common to all the Arizona-Sonora border communities. The studies mentioned above, focusing on fifth-grade students, provide an important but limited snapshot of the health effects air pollution may be having on the communities. More information is needed about children of other ages as well as adults, and it would be useful to update the study on fifth graders to reflect recent air quality trends. Aspects of additional research needed on asthma triggers relevant to children are described in much more detail in the 2004 ADEQ study. Ideally, these identified research needs would be expanded to include health effects related to air quality in addition to asthma, but because there is limited work already on asthma, and because of current activities to address asthma in all three areas and the Tohono O’odham Nation, this part of the health-related research may be easiest to accomplish.

In addition, research is needed to better characterize heavy-duty diesel truck emissions at the ports of entry in all of the communities, as well as to estimate their health impacts. An important step in this process is being carried out at the Mariposa Port of Entry,

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where a significant pilot-scale test of three technologies for measuring heavy-duty diesel truck emissions is being conducted. Results of that effort are expected to be available soon.

Another area of research that has been suggested for each of the three sister-city pairs is to investigate the degree to which one monitor on each side of the border is really adequate to represent air quality conditions throughout the area in question. In Ambos Nogales as well as Douglas-Agua Prieta, the extra monitoring sites set up in support of those studies were removed after the air quality data collection phase of the binational studies was completed. The data described above suggest conditions in Douglas-Agua Prieta may be improving, while air pollution in Ambos Nogales may be getting worse. It is not clear whether these trends would look the same if more monitoring sites were maintained.

In Yuma this issue arises in a slightly different context. The one PM monitor that has been in operation there for many years has shown a trend going from violations of the standard to compliance, and then continuing reductions in more recent years, even though the region's population and economic activity have been growing. The planned binational study will likely determine the degree to which monitoring in other locations in the region matches with or differs from this trend. Once the data collection phases of the binational study are over, there may be a need to determine how many monitors are adequate to continue to characterize regional conditions in the future.

In addition to these areas of research need that are common to all Arizona-Sonora border communities, several additional needs have been identified that are specific to one region or another (the order presented here does not imply order of importance). First, as mentioned above, air quality appears to be improving in Douglas-Agua Prieta as well as in Yuma. Some factors that may help explain this trend in Douglas-Agua Prieta are known and described later in this chapter. However, not enough is known about why this trend is occurring to support longer-term air quality management decisions. If local officials could be reasonably certain what factors within their control have helped or could help achieve a positive result, then they would be in a better position to ensure implementation of those activities in the future.

Second, there is a need for ozone and carbon monoxide monitoring in Ambos Nogales to determine whether or not the community may have a compliance issue. The limited monitoring of each parameter that was conducted in 1995 did not occur during the seasons in which those parameters are known to show the highest concentrations.

Third, research needs to be conducted on the potential effects of agricultural burns that include pesticide residues in the Yuma-SLRC area. HAPs regulated under the Clean Air Act do not include pesticides, which means pesticides were not included in pollutants scheduled for attention in the existing studies. In addition, it is not known whether the burning of agricultural crop residues in fields that have been treated with various pesticides may create combustion byproducts not traditionally covered in studies of air pollution from more common combustion sources, such as mobile sources and residential fire places.

COMPARATIVE STATUS OF AIR QUALITY IMPROVEMENT ACTIVITIES, CURRENT AND PLANNED

As described above, each sister-city pair along the Arizona-Sonora border has had different motivations that brought them into a binational study of air quality. In all cases, those studies have been carried out with the municipal governments as primary partners. However, the manner in which each community has responded to the binational air quality study has differed, with these differences starting while the study was (or is) underway. This section describes the status of current and planned air quality improvement activities in each community.

AMBOS NOGALES

In 1995—during the early stages of the binational study in Ambos Nogales—the municipality of Nogales, Sonora, took a very important step to improve local air quality. As discussed above, it closed the municipal dump situated in the middle of town and opened a

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modern landfill to the south of the city, thus eliminating the frequent incidents of burning by scavengers recovering materials. Local residents report that air quality visibly improved after this, and air quality data trends for PM seem to support that observation.

The results of the binational study were presented to the community in August 1999 at a binational meeting in Nogales, Arizona, that included government agencies, community-based organizations, and members of the general public. As a result of the study's release, binational governmental dialogue and public outreach activities were initiated in 2001, with the goal of taking action to improve air quality, and thus public health, in Ambos Nogales. These activities were led by the Mexican and U.S. consuls in Ambos Nogales, together with ADEQ and its sister agency SIUE, and included the participation of the municipal governments on both sides of the border, various other state and federal agencies, and eventually representatives from the business, academic, and community-based organizational sectors as well. The dialogue was first constituted as the Border Liaison Mechanism Economic and Social Development Subgroup (BLM subgroup), which was later expanded and joined by the Border 2012 Ambos Nogales Air Quality Task Force. The task force was established at the BLM subgroup's request. The groups meet jointly and share much of the same membership.

While the binational dialogue was developing its full list of recommendations, several activities were proposed for immediate action. A few of these were implemented. In one, ADEQ conducted traffic count measurements on a number of unpaved roads in Nogales, Sonora, with the hope that this information would help the community determine which roads to pave first for maximum air quality benefit.

The most notable immediate action implemented was a small pilot project to promote revegetation efforts, which has bloomed into the Ambos Nogales Revegetation Partnership (known by its acronym in Spanish, ARAN). Revegetation, including the planting of trees and shrubs, is important in stabilizing the land surface, which leads to reductions in both windblown and fugitive dust.

ARAN is led by the University of Arizona and the Instituto Tecnológico de Nogales in Nogales, Sonora, and includes the active participation of more than 20 partners from local schools, neigh-

neighborhood groups, the maquiladora sector, community-based organizations, municipal and state government agencies, and organizations from outside the community that bring resources such as experience, technical expertise, and sometimes financial assistance to the table.

Through the effective development and use of this network of partners, ARAN has undertaken a wide variety of revegetation activities in Ambos Nogales, including developing schoolyard habitats and school-based nurseries; training community participants in composting, water harvesting, plant cultivation, worm farming, paper recycling, and community outreach efforts involving a children's puppet show about air quality; establishing neighborhood gardens; securing and improving neighborhood green spaces; improving the municipal nursery in Nogales, Sonora; and many others.

The most advanced of all air quality improvement efforts resulting from the binational dialogue, ARAN's effective use of partnerships serves as a model for implementing other air quality improvement activities in Ambos Nogales. Although a large-scale "greening" of Ambos Nogales may still be distant, ARAN has demonstrated resilience in the face of changes within any one partner organization—a constant feature of social institutions in Ambos Nogales. This resilience suggests ARAN's efforts will be sustained well into the future, whereas many other community-based efforts in Ambos Nogales have lasted only as long as project funding was available.

The binational dialogue led to the identification of 12 recommended actions that should be taken to improve air quality in Ambos Nogales. The implementation status of each of these is shown in Table 3. A review of this information reveals several interesting points. Of the 12 recommended actions, three have both active leadership on at least one side of the border and a draft action plan to help guide implementation. Positive results have been achieved for all three of these actions: ARAN's efforts to promote revegetation, as described above; the receipt by the municipality of Nogales, Sonora, of BECC certification for a major project to pave roads; and the promotion of bicycle use. Another four of the recommendations have active leadership but no developed action plan; of

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these, three have shown important progress—those focusing on speeding up border crossings, addressing the impacts of the train route, and promoting recycling.

Two recommendations have draft action plans but no active leadership. In these cases, important progress is expected in the near future; however, this progress depends on pilot project grant funding. Not surprisingly, two of the three recommendations that have neither active leadership nor an action plan have seen no progress; the third recommendation that fits those criteria (diesel school bus retrofits) has seen progress because grant funders were eager to move forward on addressing vehicle emissions.

These findings suggest that where active leadership exists, the existence of an action plan seems to have little impact on achieving forward progress. On the other hand, in the absence of active leadership the existence of an action plan can be helpful to obtain funding that will support progress.

The ability or opportunity to work in partnerships appears to have some degree of correlation with the amount of progress that has occurred. The importance of partnerships for ARAN's success has already been mentioned; this partnership formed as a result of BLM subgroup activities. Activities pursuant to the other four recommendations that have realized important progress seem to have had the advantage of well-defined and/or well-understood processes carried out by individuals operating within existing institutional networks, although it should be noted this is an untested hypothesis. In the case of the two recommendations for which progress is expected in the near future (eliminate garbage-burning and reduce wood-burning), it is hoped that partnership networks similar to ARAN will be established as a result of the pilot projects. The remaining five recommendations for which little progress has occurred appear to be challenged by varying combinations of unclear processes, leaders who are not engaged in existing networks that could help achieve implementation, or a need for a new network of institutional partnerships in situations where no activity is either currently occurring or is anticipated to establish such partnerships. It should be noted this, too, is an untested hypothesis.

Table 3. Implementation Status of Air Quality Improvement Activities in Ambos Nogales

Recommended Action	Leaders Identified*	Action Plan Developed**	Primary Implementation Activities	Status of Implementation
A. Stabilize unpaved roads and parking lots	Yes	Yes	BECC-certified program to pave roads in Nogales, Sonora, somewhat targeted according to air quality	Seeking NADB financing
B. Speed up border crossings	Yes	No	FAST and SENTRI lanes being constructed at ports of entry; CyberPort and CANAMEX improvements	Nearing construction of lane improvements; seeking financing on other activities
C. Address vehicle emissions	No	No	Diesel school bus retrofits grant; remote sensing pilot project to characterize diesel truck emissions at border	Setting up contract agreement on retrofits; remote sensing field work nearly complete
D. Construct major corridors	No	No	None	Not started
E. Address impact of train route	Yes	No	First traffic bridge over train route in Nogales, Sonora	Under construction
F. Eliminate garbage burning	No	Yes	Pilot Project to Assess Contributions of Small-Scale Burning to Ambient Concentrations of Air Toxics	EPA funding offered
G. Promote revegetation efforts	Yes	Yes	Ambos Nogales Revegetation Partnership (ARAN)	Network of partners moving from pilot to larger scale activity

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Table 3. continued

Recommended Action	Leaders Identified*	Action Plan Developed**	Primary Implementation Activities	Status of Implementation
H. Reduce wood burning	No	No	Thermally designed housing and alternative heating/cooking pilot program	Setting up contract agreement
I. Implement technical solutions to soil erosion	Yes	No	None	Not started
J. Promote recycling	Yes	No	Santa Cruz County recycling program	Nearing completion of grant implementation
K. Improve local transit	Yes	Yes	Border PACT grant to explore promoting bike use	Nearing completion of bike use project
L. Improve traffic flow on local streets	No	No	None	Not started

*Leaders Identified: Officially, leaders in both countries have been identified for all of the recommendations. A “Yes” in this table indicates the leaders from at least one side of the border have either been active in implementation or, if not, then they at least accept this role and are integrated into the Ambos Nogales Air Quality Task Force.

**Action Plan Developed: The Ambos Nogales Air Quality Task Force has agreed that the leaders for each recommendation should develop action plans to guide implementation; these simple guides focus on identifying information such as how much emissions reductions may be realized, how much the recommendation could cost, who the implementation partners should be, how the potential effectiveness of the recommendation will be evaluated, among others. A “Yes” in this table indicates a draft plan has been developed addressing implementation on at least one side of the border.”

Source: Authors

DOUGLAS-AGUA PRIETA

It was obvious from the start of the binational study in Douglas-Agua Prieta that both municipal governments were intent on making the project a success, and both governments were ready to use the study results as a means to find funding sources to mitigate local air quality problems. Also, the willingness of Agua Prieta's officials to work across political party lines for the benefit of their community has been exemplary.

During the early stages of the binational study in 2001, the old municipal dump was permanently closed and replaced with a modern landfill located on the southeast edge of the city, away from the prevailing wind pattern. In addition to moving landfill activities to a better location from an air quality perspective, the modernization resulted in a cessation of the burning activities that had occurred at the old dump during much of the year. In addition, an intensive reforestation effort led by the Agua Prieta mayor's office, consisting of the distribution of 300 trees every weekend, is a part of the city's strategy to improve air quality.

Also in 2001, the *municipio* of Agua Prieta, using ADEQ's data and technical support, started to seek BECC certification for a project to mitigate the dust problem, improve traffic flows, and increase the percentage of paved roads in the city from 19.7% to 27%. The project entailed paving 19.5 miles of existing unpaved roads, modernizing Highway 2, and building bridges to provide better access to different points in the city. On December 17, 2002, Agua Prieta's "Reduction of Suspended Air Particles through Paving" project became one of the first two BECC-certified projects related to air quality (a Ciudad Juárez road-paving project was the other). In December 2003 the North American Development Bank (NADB) approved a \$4 million loan to pave 16.7 miles of roads in Agua Prieta. This project has since been completed.

As noted in the previous section, air quality appears to be improving in Douglas-Agua Prieta. This is believed to be a direct result of the ongoing efforts. The proactive role of the two municipal governments, as well as improved air quality in the study area over the last few years, have altered ADEQ's plan to follow the Ambos Nogales model for outreach and governmental dialogue.

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Although the binational study has not yet been completed, there is a growing feeling that an Ambos Nogales-style binational dialogue may not be necessary.

YUMA-SAN LUIS RÍO COLORADO

Because the binational study in Yuma-SLRC is at such an early stage, it is not yet appropriate to identify trends or offer hypotheses regarding how or why emission reduction activities are or are not progressing. However, it is possible to identify two sources of PM pollution that either do not exist or exist on a significantly smaller scale in the other sister-city pairs: commercial agricultural activities, including agricultural burns, and brick kiln operations. The municipality of SLRC has already begun an effort to address the brick kilns. Preliminary discussions have been held with kiln operators about the possibility of relocating their operations, although these discussions have been hampered by concerns about land ownership. In addition, the municipality is cooperating with a research effort by Arizona State University to better characterize the degree to which brick kilns affect local air quality, through partitioning studies of PM collected on air quality sampling filters.

SIMILARITIES AND DIFFERENCES

Comparing the status of implementation activities related to emission reduction at this time in the three sister-city pairs, it is easy to conclude that there has been much more activity in Ambos Nogales than in the other two areas. However, the binational study for Ambos Nogales was completed several years ago while the binational study in Douglas-Agua Prieta is still underway and, in Yuma-SLRC, has only recently begun. A better basis of comparison would be to look at implementation activities during comparable phases of the binational studies, rather than in the present year. Several interesting points emerge; these are introduced here and discussed in more detail in the following section.

An obvious similarity among all three sister-city areas is that the phases involved in conducting the binational air quality study in each share the same design. Lessons learned in each binational study

have allowed improvements to be made within this framework for the next community studied. This continuity may reflect the effectiveness of ADEQ working directly with Sonoran municipal authorities on various aspects of the binational studies, with support and approval from SIUE. The three communities share many types of primary emission sources, although there are a few exceptions noted above, and the relative contributions of source types vary among the three areas.

The differences among these three areas begin with the fact that population and economic growth rates are not the same in each area. Also, the overall air quality situation, including both compliance status and trends over time, is markedly different in each of the three areas. Although it has been possible to conduct the binational air studies with the same phases in each area, the differences will require varying approaches to emission reduction activities in each area. It is not clear whether compliance status drives local leadership, local leadership drives compliance status, or compliance status and local leadership are only circumstantially related; nevertheless it is clear that in Douglas-Agua Prieta, effective leadership by local authorities has resulted in several major air quality improvement actions being completed before the binational air quality study has concluded. In contrast, major air quality improvement actions were not undertaken at the same level in Ambos Nogales until after the binational air quality study was completed, and fewer of these efforts have reached completion or project maturity.

It is possible to identify a clear although varying level of federal role in addressing the major types of emission sources shared by the three communities. However, as individual communities add locally important sources that are not shared by all three (brick kilns in Douglas-Agua Prieta and Yuma-SLRC, electric power generation in Douglas-Agua Prieta, and agriculture-related emissions in Yuma-SLRC), the identification of a federal role generally becomes more challenging. Finally, the fact that Douglas-Agua Prieta and Ambos Nogales truly are sister-city pairs, while Yuma-SLRC is a more complex region, may require some as yet unanticipated changes in the binational study design for this area.

EMERGING PATTERNS OF SUCCESSES AND CHALLENGES

Social Infrastructure

Traditional environmental infrastructure systems, such as those for water delivery, wastewater collection and treatment, and transportation, have long been recognized as sharing certain elements in common. First, each infrastructure system has a series of essential elements. Water delivery infrastructure includes wells, treatment facilities, storage tanks, transmission lines, distribution lines, metered service connections, and indoor plumbing. Wastewater infrastructure must include service connections, lateral lines, collector lines, manholes, treatment plants, discharges, and sludge disposal. Transportation systems must have local roads, interstate highways, multimodal connection points, bus transportation and other forms of mass transit, bicycle lanes, and walking paths.

Second, it is widely recognized that the more redundancy and flexibility any of these infrastructures have, the better they will perform in the face of challenges, whether these challenges come as sudden emergencies (for example, a flood) or ongoing issues such as those posed by ongoing population growth and urban expansion. Third, the systems can vary dramatically in size and complexity, from systems serving a small rural community to those serving a major metropolitan area.

Social infrastructure can play an important role alongside physical infrastructure in the success of efforts to address environmental problems. This has been recognized only recently, and to a limited extent, in the environmental arena. Social infrastructure is the networks of people and institutions who work together toward a common goal, and it can be conceptualized in a manner similar to physical infrastructure. It, too, has a series of essential elements, such as people, institutions, and shared goals; ways and means of coming together to communicate, build relationships, implement agreed-upon activities, and interact with the larger community; and methods for identifying how new participants will join, new directions will be pursued, and challenges will be met. As with physical infrastructure, social infrastructures perform better in the face of challenges if they have more robustness and flexibility built into

their structures. Likewise, they can also vary dramatically in size and complexity, as well as in their degree of formality, in terms of both how extensive their rules of operation are and how consciously recognized the network is by its participants.

In discussing the Agua Prieta road-paving project with project participants, it becomes clear Douglas and Agua Prieta have enjoyed a well-developed social infrastructure for environmental work before and throughout the binational study period. Participants often cite continuity within the municipal government through multiple changes in administration and across party lines as one factor contributing to the community's success.

In addition, participants cite a strong history of municipal authorities in Douglas and Agua Prieta working together on environmental projects. One example prior to the recent road-paving project was that Douglas would donate its millings from road repaving projects to Agua Prieta to be used in efforts to better stabilize unpaved roads. Millings are considered a commodity throughout Arizona; thus, Douglas' willingness to donate them to Agua Prieta rather than sell them in the domestic market speaks to the willingness of municipal authorities to support each other.

This crossborder collaboration extends to community-based organizations as well. The Enlace Ecológico, which includes the participation of municipal authorities in Agua Prieta, has collaborated closely with the Border Ecology Project, based in Bisbee. Together, these organizations succeeded in addressing a number of issues related to copper smelters in the region before the binational air quality study even began. Many people have cited this social infrastructure as being directly responsible for the success of the recent Agua Prieta road-paving project, in which the roads paved were chosen specifically and exclusively as those most likely to contribute to improving air quality.

Another example of successful social infrastructure is ARAN. Unlike Douglas-Agua Prieta and its road-paving project, Ambos Nogales had no pre-existing social infrastructure around the issue of revegetation. More broadly, residents of Ambos Nogales have contrasted their own social infrastructure with that of Douglas-Agua Prieta, although many instances of crossborder collaboration between the two municipalities could be cited. Nogales, Sonora, has

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a long history of lack of continuity from one municipal administration to the next, even though the changing administrations have belonged to the same political party. In addition, although an organization called Living Is For Everyone in Nogales, Arizona, accomplished much of the consciousness-raising about health effects (lupus and multiple myeloma) that led to the binational air quality study, that group had no counterpart across the border with which to collaborate. In this context, ARAN established its social infrastructure largely in a vacuum. Local residents have provided much of the ongoing leadership of ARAN, although initial leadership came from the University of Arizona. This outside assistance—well-tuned to local needs, motivations, and priorities—may have been critical to the ability of such an infrastructure to become established in Ambos Nogales.

One important and shared characteristic of the social infrastructure in both Douglas-Agua Prieta and ARAN has been the fact that local Sonoran residents have participated in these collaborative efforts as equal partners to their Arizona counterparts. It is common for some U.S. participants in border environmental efforts to view their Mexican counterparts as so lacking in financial resources as to present a potential drain for all resources available. However, both the Douglas-Agua Prieta and ARAN partnerships have demonstrated that what the Sonoran participants may lack in up-front financial resources they more than make up for in human capital, energy, and creativity. The Sonoran contribution has been critical to the success of both networks, and ultimately it is the success of these collaborations that has attracted significant financial resources to the projects proposed by both.

These experiences offer several lessons to the Yuma-SLRC region, where the most recent binational effort has been initiated. First, as far as the authors know, Yuma-SLRC does not enjoy the kind of pre-existing social infrastructure that Douglas-Agua Prieta has had. This is most likely due to the multi-faceted nature of the Yuma-SLRC area, where the development of such networks would be highly challenging. Local participants in air quality efforts would be well advised to seek opportunities to build partnerships through focused

air quality improvement actions even during the earliest stages of the binational study. Preliminary efforts to address emissions from brick kilns may be a good candidate for this purpose.

A second lesson is that where established and relevant social infrastructure exists, local leadership to implement air quality improvement actions arises naturally. Where such infrastructure does not already exist, it can be successfully established. Initial assistance in the form of outside leadership can be quite helpful if conducted correctly. This assistance may even be essential—after all, there must be reasons why local residents and institutions have not been able to establish those networks already in Yuma-SLRC.

Another factor that may help with the establishment of relevant social infrastructure is public outreach, because of its key role in raising awareness among citizens. Although ADEQ has implemented some exemplary outreach efforts in Ambos Nogales, community leaders have often reiterated that these efforts will not be sufficient to create the kind of atmosphere for progress that is needed until many local residents are exposed to air quality data on a regular basis, such as through Air Quality Index/Índice Metropolitano de la Calidad del Aire (IMECA) reporting. In addition, Sonoran officials have repeatedly lamented what they see as a lack of sufficient environmental culture in Mexico, which impedes environmental progress. They believe additional outreach is essential to changing that culture.

THE CONTEXT OF SPECIFIC EMISSION SOURCES

The similarities and differences among the various important sources of emissions in each sister-city pair have been reviewed above. Regardless of these variations and similarities, each of those emission sources exists in its own framework of laws, policies, social driving forces, levels of relevant governmental authority, and the roles of individuals. To address any source successfully, one must first fully understand that framework. Furthermore, past successes in the Arizona-Sonora border communities have involved going beyond initial understanding of that framework to exercise out-of-the-box thinking about the particular emission source.

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The efforts to introduce special commuter lanes at the border in Ambos Nogales had to overcome a history of institutional resistance. Similarly, Agua Prieta chose to finance its road paving without relying on the neighborhood financial contribution traditionally practiced elsewhere; as a result, the roads paved were chosen strictly for environmental reasons, rather than being influenced by which neighborhood happened to assemble its financial contribution first. As another example, ARAN had to overcome the traditional thinking that revegetation efforts, which are as much about community beautification as they are about improving air quality, would not be a priority for people who are not financially well-off.

In addition to the need for creative thinking about emission sources common to the three sister-city pairs, there are some unique sources that may be more difficult to address because of a lack of previous experience in the Arizona-Sonora region. Brick kilns are one example. While Arizona-Sonora efforts can certainly draw upon the experience of the Paso del Norte airshed in addressing brick kilns, it should also be recognized that the level of relevant social infrastructure in Paso del Norte—including eight universities and institutions of higher learning, a large point source emitter with a legal obligation to invest in emissions reduction activities, and several international public health organizations with a long history of collaboration—will never be matched along the Arizona-Sonora border. Another example is emissions associated with agricultural tillage practices and agricultural burning. Although some efforts have addressed emissions from these kinds of sources in the United States, there has not previously been a binational effort along the U.S.-Mexican border to address such emissions.

ACTIVITY DESIGN AND TARGETING: WHAT CAN BE CONTROLLED

Successful efforts by Douglas-Agua Prieta, ARAN in Ambos Nogales, and others described above show the design and targeting of emissions reduction activities can be effectively controlled by local participants. Particularly in the case of Douglas-Agua Prieta, this successful design and targeting of emissions reduction activities

may play a role in why local air quality has been improving in recent years. Undoubtedly, successful design and targeting is directly related to why the ARAN partnership has developed so effectively.

At the same time, other ideas have been proposed that reflect good design and targeting and yet they have not been implemented to date. The reasons have not been fully evaluated, although the factors described above suggest that lack of social infrastructure likely plays an important role. Other factors may include lack of prior experience, difficulties associated with promoting and executing out-of-the-box thinking, and an inability of local and state leaders to act on their good plans for various reasons. A thoughtful evaluation of the reasons that various activities have not yet been implemented—one that does not point fingers at particular people but instead looks for unused opportunities—would be helpful.

POPULATION GROWTH AND WEATHER: WHAT CANNOT BE CONTROLLED

Although the design and targeting of activities can be effectively controlled by local participants, there are other factors with the potential to affect air quality that are beyond the ability of local or even state-level participants to control. Most notable among these are the weather and population growth, and associated economic growth. As described earlier, the three sister-city pairs along the Arizona-Sonora border have significant differences in terms of population and economic growth.

There has been relatively little growth in Douglas-Agua Prieta, and this situation is expected to continue for the foreseeable future. It is not known to what degree the local improvement of air quality is attributable to specific emissions reduction activities taken by the community, or simply due to a combination of low growth rates and lucky weather conditions.

Yuma-SLRC, while much bigger than Douglas-Agua Prieta, also has experienced a lower growth rate than Ambos Nogales. This may help explain why Douglas, which has been in nonattainment status but has seen a reduction in 24-hour PM₁₀ concentrations, may soon be redesignated as a “maintenance” area. A violation of the 24-hour standard that occurred in 2002 was a potential obstacle to that

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redesignation, but it was subsequently determined to be the result of a high wind episode, a natural event that justifies a waiver by EPA. The community hopes implementation of BACM and a public education program, as required under a NEAP, as well as submittal in summer 2006 of a Maintenance Plan and re-designation request to EPA, will help complete the process of being reclassified.

Ambos Nogales, on the other hand, has continued to experience dramatic population and economic growth in spite of the economic downturn of recent years. As noted above, this growth may explain why the community has returned to violations of air quality standards in recent years. The most recent data available have shown air quality improvements, which may be related to a mild winter. All these factors are beyond the control of local leaders. In addition, the high rates of population and economic growth may be an obstacle to more extensive efforts to establish successful social infrastructure to address environmental issues.

RURAL NEEDS VIS-À-VIS NATIONAL POLICY INITIATIVES

Because national policy initiatives often tend to be informed by a perspective that focuses on the grand scale and large populations, the needs of rural areas can easily be overlooked or lost amid the many competing priorities. In spite of this, both Douglas-Agua Prieta and Ambos Nogales have made progress by taking advantage of the expanded mandate of BECC and NADB, which added air quality as an area of concern in 2000 (see Chapter VII). As mentioned above, Agua Prieta has already completed its road-paving project with NADB financing. Nogales, Sonora, has received BECC certification for its road-paving project and is currently pursuing NADB financing.

However, there are a number of other issues on which the Arizona-Sonora rural sister cities need policy attention at the federal level. Some of these needs are likely to gain that attention in coming years because they are also shared by larger, more urbanized areas in the two countries. One example is the need to make ultra-low-sulfur diesel fuel available throughout Mexico. This fuel will reduce PM somewhat in existing engines, but more importantly will

be the only fuel that new engines in model year 2007 can use, and those new engines will reduce PM and NO_x dramatically. A second example is the development of PM_{2.5} standards in Mexico, thus establishing a regulatory framework parallel to the existing one in the United States.

Other rural issues may be harder to address in a national program. It has already been mentioned that efforts to address agricultural emissions will be new in the binational context. Also, establishing a social infrastructure to address specific air quality issues, where none exists now, may be challenging without outside help.

Addressing sources where no social infrastructure exists and where defining a federal role is difficult may be doubly challenging. One such issue on which the Arizona-Sonora border region hopes to see some progress in the coming year is wood-burning in Ambos Nogales. EPA funding has been made available through ADEQ to support a community assessment by the University of Arizona similar to that which established the ARAN partnership. The project workplan defines federal and state roles intended to result in the development of social infrastructure. If success is attained, then a desirable role for the federal government may be to help finance the larger-scale implementation of approaches to reducing wood-burning that are identified in this pilot project. This may include, for example, the use of mechanisms established by the Kyoto Accord (see Chapter VI).

At the state level, ADEQ has undertaken a project to improve the environmental health conditions of children. One of the key priority concerns is identifying asthma triggers and undertaking binational outreach efforts to inform school officials and other local leaders, parents, and children about asthma and how to treat it. While this program focuses on one population group, the overall research and outreach efforts will benefit all residents of the border. Effective communications and practical low-cost opportunities, such as voluntary reduction of school bus idling, are the mechanisms being developed for this project within the border region. Although these efforts have had some success to date, they could be more effective if better data were available about asthma rates and the prevalence of a variety of asthma triggers, including air quality.

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Although limited research on these issues has been conducted along the Arizona-Sonora border, most such border area research is conducted in larger population centers elsewhere on the U.S.-Mexican border.

FINANCING IS KEY—OR IS IT?

One final pattern of successes and challenges worth exploring further has to do with the financing of air quality improvement efforts. Several efforts to obtain financing have been mentioned above. In fact, all successful efforts to reduce emissions that have been implemented to date along the Arizona-Sonora border have needed and obtained significant levels of financing. However, funding has not created the social infrastructure networks that have also been so key to various projects' success. On the contrary, it has been seen that the opposite happens: once a network is successfully established, then that network is able to attract the necessary financing. Thus, while funding is necessary for emission reduction actions to be implemented, a relevant social infrastructure may be an essential pre-requisite to obtaining and using the available funding.

CONCLUSIONS

Rural Conditions in a Binational Program: The Square Peg

The previous section explored several of the difficulties faced by rural areas participating in a binational program. In short, the Arizona-Sonora border area will never have the high level of resources and institutional frameworks present in areas like the Paso del Norte airshed or San Diego-Tijuana. In addition, it can be challenging to define a federal role in addressing some of the pollution sources important to various parts of the Arizona-Sonora border, but that are not necessarily important sources in larger and more urban settings. Nevertheless, certain advantages have been identified with respect to rural areas. Chief among these is that establishing social infrastructure associated with binational cooperative air quality efforts may be simpler than in larger areas. The Arizona-Sonora bor-

der region should take better advantage of its state-to-state network for cooperation in order to help transfer lessons learned among its sister cities and to help create needed social infrastructure where it is currently lacking.

PRIORITY POLICY ISSUES NEEDING ATTENTION

It is relatively easy to identify those interests of one or both of the federal governments that benefit both the urban areas and the rural areas. These include making ultra-low-sulfur diesel fuel available throughout Mexico, establishing PM_{2.5} standards in Mexico, and upgrading the infrastructure at ports of entry. Continuing progress in these and other areas where the federal role is clear will be helpful to Arizona-Sonora's border area.

Equally important are federal and state resources to help establish local social infrastructure where needed to address specific and locally important emission sources, regardless of the importance of those sources in urban areas or at a national level. Even when no other specific federal role can be defined, the ability of the federal governments in both countries to offer financing mechanisms often transcends the capabilities of state, and especially local, governments. At the same time, the first focus of that funding, or of local efforts leading to funding, should be the establishment of effective partnerships among stakeholders.

SUCCESSSES, CHALLENGES, AND THEIR BROADER LESSONS

Much of this chapter has focused on comparing and contrasting the three primary sister-city pairs along the Arizona-Sonora border, and some attention has also been paid to the challenges and opportunities posed by being a rural area in a federal, binational program. However, the Arizona-Sonora border region does have some lessons to offer the rest of the U.S.-Mexican border region on air quality.

First, the Agua Prieta road paving project was one of the two projects first certified by BECC and financed by NADB when those institutions added air quality to their portfolio of criteria. That project established a standard by which environmental improvement

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drives the decision-making, and financing methods follow, rather than the other way around. The entire border area would benefit from adopting this model.

Second, social infrastructure is very important to success, including success at obtaining significant funding for air quality improvement actions. The experience in Douglas-Agua Prieta demonstrates how any community with an existing social infrastructure can take advantage of that infrastructure to realize measurable air quality improvements. In Ambos Nogales, ARAN is an example of how effective, relevant networks can be established where they did not previously exist.

Third, it is often true of successful binational air quality improvement efforts that the Sonoran participants contribute as equal partners with the Arizona participants. Recognizing that financial resources are not the only resources that matter, and that Mexican stakeholders can more than make up for having less money with the creativity and energy they bring to the table, can be a valuable step forward for any community seeking to accomplish binational air quality improvements.

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III

Improving Air Quality in Paso del Norte

Bob Currey and Ross Pumfrey

ABSTRACT

The Paso del Norte region is an airshed that comprises portions of three states (Texas, New Mexico, and Chihuahua) in two countries (the United States and Mexico). Air quality in this region has been a problem since initial monitoring began in the 1970s and 1980s. El Paso, Texas, was officially declared in violation of the U.S. health-based standards for ozone and carbon monoxide in the 1970s and in violation of the standard for particulate matter in 1990. Other areas in the region had similar problems. A number of actions were taken by federal, state, and local governments in both countries over a period of several years and an innovative, inter-jurisdictional mechanism for developing mutual strategies was created. Air quality has improved measurably and redesignations of El Paso's status under U.S. regulations are in process. This success is due to a combination of factors: the national regulatory framework, state and local government programs, favorable natural and climatological conditions, and local (but binational) stakeholder-based activity and advocacy. Yet, perversely, some of the same things that have worked for the improvement of air quality have also worked in other ways to its detriment. The net result, however, is positive.

Mejora de la Calidad del Aire en Paso del Norte

Bob Currey y Ross Pumfrey

RESUMEN

La región Paso del Norte es una cuenca de aire que comprende porciones de tres estados (Texas, Nuevo Mexico y Chihuahua) en dos países (México y los Estados Unidos). La calidad del aire en esta región ha sido un problema desde que inició el monitoreo en las décadas de 1970 y 1980. En la década de 1970, El Paso, Texas, fue oficialmente declarado en violación de los estándares estadounidenses basados en la salud para el ozono y el monóxido de carbono y en 1990 en violación del estándar para materia particulada. Otras áreas en la región tenían problemas similares. Un número de acciones se llevaron a cabo por los gobiernos federal, estatal y local de ambos países en el transcurso de varios años y se creó un mecanismo innovador e interjurisdiccional para el desarrollo de estrategias comunes. La calidad del aire ha mejorado de modo medible y las redesignaciones de la condición de El Paso están en proceso bajo las reglamentaciones estadounidenses. Este éxito se debe a una combinación de factores: el marco reglamentario nacional, programas de gobierno locales y estatales, condiciones climatológicas naturales y favorables y la abogacía y actividades con base en las personas interesadas a nivel local (pero binacional). No obstante, a la inversa, algunas de las mismas cosas que han funcionado para mejorar la calidad del aire también han contribuido hacia su detrimento. El resultado neto, sin embargo, es positivo.

INTRODUCTION

The Paso del Norte region, an airshed that includes portions of three states (Texas, New Mexico, and Chihuahua) in two countries (the United States and Mexico) was declared in violation of respective national air quality standards for three different pollutants in the early 1990s. This created a challenge because of the potential hurdles implied by dealing with multiple jurisdictions and differences in legal systems, language, and cultures.

The region's air quality has been improving measurably, although the general public probably does not perceive it. Instead, people notice degraded visibility and a brown cloud and thus think the air is bad. People see a tall, dormant smoke stack at the Asarco plant, and not their tail pipe, and think the air is bad.

The very real improvements in air quality are due to a combination of factors: the national standards and regulatory framework, state and local government programs, favorable natural and climatological conditions, and local (but binational) stakeholder-based activity and advocacy. Yet, perversely, the same things that have worked for the improvement of air quality have also contributed to its detriment. The net result, however, has been positive.

This chapter provides short descriptions of the region, the original problems, and the progress made. It then examines which actions have been or have not been effective in helping bring about that progress.

AN OVERVIEW OF THE REGION

The Paso del Norte region comprises the communities of Ciudad Juárez, Chihuahua; El Paso County, Texas; and southern Doña Ana County, New Mexico. Total population is approximately 2.25 million. Ecologically, the region is high Chihuahuan desert at an altitude of approximately 4,000 feet. Average annual rainfall is nearly eight inches (the past decade has been lower), humidity is very low, winters are mild, and summers are hot and dry, with diurnal temperature variations of 30°F to 40°F. Like most of the U.S.-Mexican border, the U.S. portion of the region is economically depressed compared to the U.S. average; the Mexican side is depressed relative

to the U.S. side and economically advantaged compared to the rest of Mexico. Topographically, the region is complex terrain, with dominant mountain features that create a bowl that traps pollutants, especially during stagnant and inversion conditions.

The population in the region, which reached approximately 1.9 million in 2000, has been growing at a high rate (Federal Reserve Bank of Dallas 2001), although not any higher than some other urban areas in the U.S.-Mexican border area. The 1990s witnessed annual growth of 3.7% in Paso del Norte, which was nearly triple the U.S. national rate and nearly double the Mexican rate (disaggregating the data for El Paso and Ciudad Juárez shows the rate of growth in the latter was significantly higher than in the former).

For years the area drew attention for its poor air quality. El Paso had the dubious distinction of being the only city in the United States that was designated by the U.S. Environmental Protection Agency (EPA) as nonattainment for the National Ambient Air Quality Standards (NAAQS) for three of the six criteria pollutants—ozone (O_3), carbon monoxide (CO), and particulate matter (PM).

Monitoring of ozone and CO began in El Paso in 1970 and the data soon showed the area violated the original one-hour standard for average ozone concentrations and the eight-hour standard for average CO concentrations (Texas Natural Resource Conservation Commission [TNRCC] 2002). The first plan for addressing the problems was submitted to EPA in 1979. A new classification system established by the 1990 amendments to the Federal Clean Air Act (FCAA) designated El Paso as a “serious” nonattainment area for ozone.

Monitoring of PM_{10} (particulate matter with a diameter of 10 microns or less) began in El Paso in the late 1980s and it was clear that both the 24-hour and the annual standards were being violated. The 1990 amendments to FCAA made El Paso a “moderate” nonattainment area under the two standards.

Similarly, Ciudad Juárez exceeded the Mexican national standards (Normas Oficiales Mexicanas, or NOM). EPA designated portions of Doña Ana County nonattainment for PM_{10} and ozone.

These designations, of course, garnered widespread publicity, and much of the public still believes the problems remain unchanged. What gets the public's attention is visibility. The region is often blanketed by the aforementioned brown cloud.

The designations, however, also generated a series of national, state, and local actions on both sides of the border. Some combination of these actions appears to have worked. Air quality data in El Paso over the past 10 years to 15 years have indicated significant improvement in relation to U.S. standards for the three pollutants in question, despite population growth in the region. Likewise, monitoring data in Ciudad Juárez indicate the improvements have been basin-wide.

As a result, EPA is in the process of redesignating El Paso. First, when the designations for the new U.S. eight-hour ozone standard were announced by EPA in the spring of 2004, El Paso was declared an attainment area. Its previous status under the one-hour ozone standard became a non-issue because that standard was officially revoked in June 2005. It is worth noting that El Paso had not experienced any violations of the one-hour standard since the mid-1990s. Nevertheless, the Texas Commission on Environmental Quality (TCEQ) was required to submit what is referred to as a maintenance plan, as is required for all areas in attainment, and as part of this plan the agency left in place most of the programs that had resulted in improvement during the 1990s.

Monitors also have recorded a decreasing number of exceedances of the eight-hour CO standard since 1990, although with fluctuations as might be expected. Since 1997 technical compliance under that standard has been maintained (TNRCC 2002). In January 2006 TCEQ submitted a request to EPA for redesignation to attainment under the carbon monoxide standard. It is not known how soon EPA will be able to respond.

Finally, annual average concentrations of PM₁₀ declined significantly in the early 1990s, then more or less leveled off with fluctuations over the next few years. All monitors except one special-purpose monitor have shown compliance with the standards since 1992 (TNRCC 2002). A few issues remain with respect to PM, but at some point in the future El Paso and TCEQ hope for redesignation of El Paso for this pollutant also.

As with the ozone standard, TCEQ will be required to submit maintenance plans for CO and particulate matter, and existing control programs will likely stay in place.

Two general observations can be made. First, significant improvement occurred during the early or mid-1990s in the concentrations of all three pollutants, and the gains have been maintained. Second, this sustained improvement occurred despite high rates of population growth in the region.

NATIONAL REGULATIONS

At the top of the legal hierarchy are the standards and other requirements promulgated by the two national governments, as well as programs they implement in support of improvement. What has helped Paso del Norte?

- The air quality standards themselves (NAAQS in the United States and NOM in Mexico forced everyone to recognize the problems that existed)
- The national regulations triggered in the United States by nonattainment designations
- Auto emissions standards
- Fuel-related programs, such as lead-free gasoline, use of oxygenates, and vapor controls
- Monitoring programs

The Mexican and U.S. national standards for the criteria pollutants are, for the most part, equivalent (see Table A at the beginning of this monograph), although recent changes in U.S. ozone and particulate matter standards have created differences.

Periodic changes to standards made by EPA, specifically in what is measured or how long a period of time is averaged, have been a double-edged sword. El Paso is one of a handful of communities that could have had future problems with the old one-hour ozone standard because it is possible that part of the success of the past decade is due to Mother Nature, and that a long, hot summer like 1996 could cause problems. But, the federal change from a one-hour standard to an eight-hour standard helped define this problem out of existence. On the other hand, changing the PM standard from PM₁₀

to PM_{2.5} (particulate matter that measures 2.5 microns or less in diameter) caused many communities to cease monitoring the former, thereby losing much information that might be valuable in assessing the relation between air pollution and health effects.

U.S. fuel consumption standards and increasingly strict emission standards for automobiles have been beneficial to the nation, and to a lesser extent to the U.S.-Mexican border region. The border region will certainly reap benefits from these standards, but at a slower rate than the rest of the nation because poor economies and dry climates, where vehicles don't rust away, lead to older vehicle fleets, and older vehicles are generally dirtier in terms of emissions. Likewise, the increased marketshares of SUVs and light trucks tend to offset the automobile gains as long as those categories are treated much more leniently.

The mandate for lead-free gasoline, along with the introduction of newer-generation automobiles, may be the most significant factors in the improvement of air quality. Likewise, the use of oxygenated gasoline in winter and low Reid Vapor Pressure gasoline in summer have significantly helped mitigate the seasonal problems of carbon monoxide and ozone, respectively.

On the other hand, it would be better if these fuel programs were applied more consistently throughout the region. Currently, the New Mexico sector of Paso del Norte does not require these fuels, and the concentration of oxygenates used in fuel in Ciudad Juárez in the winter is roughly half of what is required in El Paso. But it is fortunate that the preferred oxygenate is ethanol, as the region's groundwater sources could be vulnerable to methyl tertiary-butyl ether (MTBE), especially in Ciudad Juárez where gasoline storage tanks may be more susceptible to leakage.

Another important program has been the use of vapor controls at fueling facilities. El Paso has stage I and II vapor controls in place. Ciudad Juárez and Doña Ana County have not yet instituted such programs.

U.S. mandates for diesel engine emissions and ultra-low-sulfur diesel fuels, which will be phased in over the next four years, will also bring air quality improvements. The challenge will be to foster uniformity within the airshed.

Lastly, the application of available control technologies to El Paso's most prominent industrial source, the now dormant Asarco smoke stack, in the late 1980s and early 1990s also contributed to emissions reductions that ultimately manifested in air quality improvements.

STATE AND LOCAL PROGRAMS

While national governments set standards, and proscribe selected regulations, in the United States the responsibility for execution of the regulations and adoption of implementing programs, as well as air quality management in general, lies with state and local governments.

The impact of the State Implementation Plans (SIPs), and their Mexican analog, the Pro-aire program (although, the latter is federal in design but local in implementation), cannot be underestimated. Texas has SIPs for ozone, PM, and CO in El Paso (TCEQ 2006). They mandate a variety of actions and controls to reduce emissions, including controls on burning, street sweeping programs, inspections of gas stations to ensure compliance with fuel programs, and vehicle inspection and maintenance.

State and local ambient air monitoring programs collect data concerning various pollutants, air toxics, and meteorological conditions. These data are available to the public in near real-time on websites operated by the states of Texas and New Mexico. Regional news media also provide information about the air quality index (AQI), levels of ultraviolet radiation, and pollen counts.

El Paso has an Ozone Action Day program. One function is to alert sensitive and vulnerable portions of the population when levels of ozone are expected to be higher than normal. Presumably, informed individuals may take action to reduce their exposure and mitigate the effects of this pollutant. The Ozone Action Day program includes an outreach component that recommends actions to reduce pre-cursor emissions. Those actions include reducing per person vehicle miles traveled by carpooling, using public transportation, and consolidating trips; avoiding fueling operations during midday; deferring lawn mowing; and avoiding drive-thru lanes and excessive vehicle idling. At present, these actions are voluntary.

Improving Air Quality in Paso del Norte

Residents of Ciudad Juárez and Doña Ana County are exposed to the El Paso program's notices through shared media outlets. In addition, the Texas Department of Transportation conveys Ozone Action Day alerts on electronic road-side media in the city.

Through the Clean Cities program, sponsored by the U.S. Department of Energy, El Paso has increased the number of vehicle fleets using alternative fuels.

Ciudad Juárez periodically sponsors Ecological Fairs that provide citizens with a wide variety of environmental information, especially concerning ways to minimize environmental risks. One of the important messages disseminated is that a well-maintained automobile is likely to have cleaner emissions.

Both El Paso and Ciudad Juárez have inspection and maintenance programs for automobiles, although the degree of compliance and enforcement may be considerably less than program officials would like to admit.

Inconsistent application of air quality programs and unequal or nonexistent enforcement of regulations are also factors that work against air quality improvement in multi-jurisdictional regions. One of the principal causes of these inconsistencies is the notion that we can manage environmental conditions along environmental boundaries. Nowhere is this more evident than in the Paso del Norte region, where an electric power plant located within three miles upwind of downtown El Paso, but in the state of New Mexico (and therefore not in the El Paso nonattainment area), is less strictly regulated than two power plants in the northeast quadrant of El Paso County that are 20 or more miles, and not upwind, from downtown. Management of air quality in the Paso del Norte region would likely be more effective if EPA would exercise its authority under Section 107(c) of FCAA to declare the entire U.S. portion of Paso del Norte an interstate air quality control region.

Creation of an interstate air quality control region could eliminate one of the barriers to consistency in management of air pollution. Currently, New Mexico's Air Quality Act provides that the state may not adopt regulations more stringent than those of the federal government in four areas governed by it: performance standards, prevention of significant deterioration, non-attainment, and

visibility. Because the Doña Ana ozone nonattainment area is not classified as severe or serious, the state will not apply requirements for vehicle inspection and maintenance or fuels programs.

LOCAL, BINATIONAL STAKEHOLDER-BASED ACTIVITY AND ADVOCACY

The involvement of citizen stakeholders in regional air quality issues predates both the U.S.-Mexico Border 2012 program and its predecessor, Border XXI. In 1993 the Paso del Norte Air Quality Task Force was created with the strong support and involvement of a variety of organizations and individuals from both sides of the border. A principal thrust of the task force was advocacy for the establishment for an International Air Quality Management District—a mechanism to conduct basin-wide air quality monitoring, planning, and management.

With the strong encouragement of the governors of Texas and Chihuahua, the two nations used the framework of the 1983 La Paz Agreement to establish the Joint Advisory Committee for the Improvement of Air Quality in the Ciudad Juárez, Chihuahua, El Paso, Texas, Doña Ana County, New Mexico Air Basin (JAC) in 1996 (Appendix I to Annex V) (Government of the United States of America and Government of the United Mexican States 1996). That 20-member body is co-chaired by representatives of EPA and the Mexican Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) and includes representatives of state and local agencies from all three states, as well as a mix of private individuals representing the corporate, academic, health, and community sectors.

JAC meets quarterly. Its purpose is to develop, promote, and recommend measures to improve the region's air quality, and it has enjoyed several successes:

- Distribution of oxygenated gasoline in Ciudad Juárez during winter months
- Texas legislation that permits Supplemental Environmental Program funds to be used outside the boundaries of the state when they produce improvements in the state, the so-called International Supplemental Environmental Program (ISEP)

Improving Air Quality in Paso del Norte

- Texas legislation that recognizes certain cross-border, cross-pollutant emissions reductions
- Design and construction of new-style brick kilns in Ciudad Juárez; the “environmental brick kiln” has up to 88% fewer emissions than the kilns that have been traditionally used in this micro-industry
- Integration of the Ciudad Juárez continuous air quality monitoring network into TCEQ’s air quality monitoring network
- Completion of an emissions inventory of area sources
- Establishment of a vehicle emissions testing program in Ciudad Juárez
- Expanded road-paving programs throughout the air basin
- A “cash-for-clunkers” program developed as a result of an enforcement action that resulted in 400 operating vehicles from the entire basin being traded in for cash
- Training programs in Ciudad Juárez that taught small auto paint shop operators to use low-pressure paint guns and reduce emissions of VOCs

Recently, JAC reviewed its strategic priorities and decided to focus on the principle of a unified air basin (the One Basin Resolution) and three priority areas: data, particulate matter, and mobile sources. These priorities are known to the members as the three D’s: data, dust, and driving—although both the mobile source and PM topics share a fourth D, diesel.

JAC’s One Basin Resolution, passed in 2002, is a reaffirmation of the principle of a unified approach to air quality management in a transboundary area. The resolution called on the respective local, state, and federal governments for assistance in overcoming the variety of obstacles, including legal, regulatory, institutional, technical, and fiscal barriers. The resolution listed five specific measures where such assistance is requested:

- To define accurately the physical scope of the air basin, rather than using the existing administrative and political boundaries
- To standardize monitoring, forecasting, and data collection and dissemination
- To develop a standardized and accurate emissions inventory for the air basin

Binational Air Quality Management

- To promote joint air quality modeling activities as a tool for diagnosis, planning and policy-making
- To harmonize or coordinate the respective air quality standards and management and control programs

The feeling of the JAC membership was that if it could not have a single, unified agency manage the air basin, then the preferred alternative was to work closely enough that the two countries, three states, and three local jurisdictions would be taking the same approaches and actions. In short, the goal is complementary, coordinated management activities in all three states in the basin.

Participants do not claim that everything runs perfectly. Sometimes one or more participants may take actions inconsistent with the One Basin Resolution or the concept of coordinated management. An example is New Mexico's recent development of a web-based program to disseminate the data from monitors in Doña Ana County: it is not compatible with the pre-existing system used by TCEQ to display data from monitors in El Paso and Ciudad Juárez. As a result, the public cannot go to a single site to see the readings of all the monitors in the community.

Turnover of JAC members has also been problematic, especially in the Mexican and New Mexican delegations. Likewise, attendance has been inconsistent and the committee has sometimes had difficulty assembling a quorum.

As with many binational U.S.-Mexican environmental work groups, policy forums, or task forces, it has sometimes proven difficult to get things done in the periods between the regularly scheduled meetings. JAC recently consolidated a large number of sub-committees to a reasonable number of five, an action that will increase productivity between the full committee meetings, it is hoped.

Finally, in a positive move, JAC has changed operating procedures to make it more open to the public it represents, inviting public comment at meetings and full participation in sub-committee activities.

CONCLUSIONS AND REMAINING ISSUES

With respect to national ambient air quality standards, the Paso del Norte region has made significant progress. El Paso has shed its nonattainment status for one pollutant and likely will do the same with regard to the two remaining pollutants. Ciudad Juárez is likewise improving.

The improvements in the air quality of the region have been the result of a variety of national, state, and local governmental programs; favorable natural conditions; and active binational, community-based, stake-holder initiatives. Chief among these factors are lead-free gasoline and newer automobiles. These efforts have individually and collectively worked in a positive fashion overall.

But there is still work to be done. The existence of adverse localized conditions, “hot spots,” and short-term episodes of elevated concentrations require continued effort. As an example, a recent study in Sunland Park, in southern Doña Ana County, showed that on some days the community experiences half its PM load in a three-hour evening period and that occasionally one-hour averages may be an order of magnitude greater than the daily average (Li 2005).

Emerging issues such as elevated levels of hydrogen sulfide in a portion of the airshed and proposed new NAAQS for PM require analysis, and perhaps action, to preclude the loss of the progress achieved to date. Continued engagement of citizens and governments, partly through the well-respected partnership of JAC, is necessary to avoid back-sliding and resolve the outstanding issues.

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IV

Air Quality Issues in the Four-state Border 2012 Region

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ABSTRACT

The Four-state Region (FSR), as defined by the binational Border 2012 Environmental Program, includes those portions of the Mexican states of Tamaulipas, Nuevo León, and Coahuila within 100 kilometers (km) of the international border and the counties of Texas that fall within 100 km of the Texas' border with those three states.

No areas in this region have violated any of the national standards for regulated pollutants in either country. Nevertheless, selected air quality concerns exist, most of them related to short-term local episodes but one related to a longer-term problem. These are caused either by meteorological conditions combined with the long-range transport of pollutants from outside the region, or by sporadic local air pollution events.

The population and vehicle fleet (important with respect to generating emissions) in the region are growing at high rates. The population grew 36% from 1990 to 2000 in the Mexican portion of the FSR and 42% in the Texas portion. The combined population in 2000 was 2.74 million and could reach 3.79 million and 5.27 million

in 2010 and 2020, respectively. A majority of the population of the FSR resides in the Lower Rio Grande Valley (LRGV), 1.9 million people in 2000, which comprises the counties of Cameron, Hidalgo, and Starr in Texas and the *municipios* of Matamoros, Río Bravo, and Reynosa in Tamaulipas. The population in the LRGV could reach 2.65 million in 2010 and 3.70 million in 2020. Likewise, the number of vehicles was 1.33 million in 2000 in the FSR and could reach 1.84 million in 2010, of which 1.24 million vehicles would be in the LRGV.

Long-distance transport of U.S.-generated ozone and Saharan dust cause occasional, short-term problems related more to health issues in other parts of the FSR. The possible impact of pollution carried from Monterrey is unstudied. Other concerns relate to agricultural burnings and fires at landfills and illegal dumps, and the possibility of industrial contributions to some smoke events. Additionally, the growing population and vehicle use could, over the long term, have an impact on air quality, and more immediately the increase in diesel truck traffic tied to international trade merits tracking. It is important to maintain updated data on emissions, population, and the vehicle fleet and evaluate developments in the area in order to anticipate and prevent air quality problems in the future.

A different kind of air quality concern, but an ongoing one, relates to the degradation of visibility at Big Bend and Maderas del Carmen national parks ("sister" parks abutting the border). U.S. law requires that this be addressed. Analyses demonstrate that this problem is caused by pollution (principally particulate matter) transported by winds into the western part of the region from both countries.

Temas sobre la Calidad del Aire en la Región de los Cuatro Estados de Frontera 2012

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RESUMEN

La Región de los Cuatro Estados (por sus siglas en inglés, FSR), de acuerdo con la definición del Programa Ambiental binacional de Frontera 2012, incluye las secciones de los estados mexicanos de Tamaulipas, Nuevo León y Coahuila que se encuentran dentro de 100 kilómetros (km) de la frontera internacional y los condados de Texas que están dentro de 100 km de la frontera de Texas con estos tres estados.

Ninguna de las áreas en esta región ha violado ninguno de los estándares nacionales para contaminantes regulados en ambos países. No obstante, existen ciertas preocupaciones en cuanto a la calidad del aire. La mayoría de éstas se relacionaron con episodios locales de plazo corto, pero uno se relacionó a un problema de un plazo más largo. Estos son causados ya sea por condiciones meteorológicas combinadas con el transporte a gran distancia de contaminantes desde fuera de la región, o bien, por eventos locales esporádicos de contaminación del aire.

La población y la flota vehicular (importantes con respecto a la generación de emisiones) en la región están creciendo a ritmos acelerados. La población creció 36% de 1990 al año 2000 en la parte mexicana de la FSR y 42% en la parte texana. La población combinada en el año 2000 fue de 2.74 millones y podría alcanzar 3.79 y 5.27 millones en los años 2010 y 2020, respectivamente. La región de la parte inferior del Río Bravo (Lower Rio Grande Valley LRGV), donde reside la mayoría de la población de la FSR,

comprende los condados de Cameron, Hidalgo y Starr en Texas y los municipios de Matamoros, Río Bravo y Reynosa en Tamaulipas. La FSR tenía una población de 1.9 millones en el año 2000. La población en el LRGV podría alcanzar 2.65 millones en el año 2010 y 3.7 millones en el año 2020.

De la misma manera, la flota vehicular era de 1.33 millones en el año 2000 en la FSR y podría alcanzar 1.84 millones en el año 2010, de los cuales 1.24 millones de vehículos están dentro de la LRGV. El transporte a gran distancia de ozono generado en los Estados Unidos y polvo del Sahara causan problemas ocasionales de corto plazo relacionados más con cuestiones de la salud en otras partes de la FSR. El posible impacto del transporte de contaminantes desde Monterrey no ha sido estudiado. Otras preocupaciones están relacionadas con las quemas agrícolas, los incendios en los rellenos sanitarios y los tiraderos ilegales y a la posible contribución de las industrias en episodios de contaminación por humos. Adicionalmente, la creciente población y uso de vehículos podría, en el largo plazo, tener un impacto en la calidad del aire. En un plazo inmediato, merita dársele seguimiento al incremento en el tránsito de camiones diésel vinculado con el comercio internacional. Es importante mantener datos actualizados sobre las emisiones, de población y de la flota vehicular y evaluar lo que acontece en la zona para prevenir problemas de calidad del aire en el futuro.

THE FOUR-STATE REGION

The Four-state region (FSR), as defined by the binational Border 2012 Environmental Program, includes those portions of the Mexican states of Tamaulipas, Nuevo León, and Coahuila within 100 kilometers (km) of the international border and the counties of Texas that fall within 100 km of the border with those four states. Figure A the beginning of this monograph is a map of the entire U.S.-Mexican border region, and the easternmost portion of the border is the FSR.

The FSR stretches along the Rio Grande (Río Bravo in Mexico) for approximately 450 miles, from the area known as Big Bend to the Gulf of Mexico. Cross-border “sister cities” have emerged as a

result of traffic, commercial, and industrial activities. The major sister cities are Del Rio-Ciudad Acuña, Eagle Pass-Piedras Negras, Laredo-Nuevo Laredo, McAllen-Hidalgo-Reynosa, and Brownsville-Matamoros. Diverse ecosystems are found in the region, including part of the Chihuahuah Desert, subtropical brushland, and Gulf Coast wetlands.

The volume of trade crossing the border at Laredo-Nuevo Laredo makes that port of entry the largest inland port in the entire United States. Matamoros, which is the largest Mexican city in this region, is the home of two large industrial parks composed chiefly of maquiladoras. The region has good air quality; no areas on either side of the border are in violation of the respective national air quality standards. In Mexico, however, a large municipio very close to the FSR, Monterrey, does have serious air quality problems. Many of the air issues identified in this chapter pertain to short-term events caused by locally generated extraordinary emissions, with few cases of regional concern. The latter derive principally from pollutants coming from other areas, as discussed later in this chapter.

Population in the Four-state Region

The population of the FSR has increased at a relatively high rate in the last two decades, due at least in part to the maquiladora program that began in Mexico in the mid-1960s. The growth accelerated somewhat in the 1990s when the North American Free Trade Agreement (NAFTA) went into effect. Table 1 shows the population in 1980, 1990, and 2000 in the FSR. The municipios within 100 km of the border in Coahuila, Nuevo León, and Tamaulipas had a population of nearly 2.60 million in 2000 (Municipios de Mexico 2005 and Instituto Nacional de Estadística Geografía e Informática 2005), having experienced a growth rate of approximately 25% from 1980 to 1990 and then 26% from 1990 to 2000.

The population of the Texas counties that fall within the FSR was 1.39 million in 2000. The growth rate had been 26% from 1980 to 1990 and then 35% from 1990 to 2000 (U.S. Bureau of the Census 2001).

If the growth rates on each side of the border from 1990 to 2000 continue for the period 2000 to 2010, the population in 2010 will be slightly more than 3.27 million in the Mexican portion of the FSR and nearly 1.88 million in the Texas portion, for a total of nearly 5.14 million people. Maintaining the growth rates until 2020 would result in a total regional population of approximately 6.64 million.

The most populous and fastest growing portion of the FSR in both countries is in the sub-region nearest the Gulf of Mexico, known on the Texas side as the Lower Rio Grande Valley (LRGV). This includes the counties of Cameron and Hidalgo in Texas and the neighboring municipios of Matamoros, Río Bravo, and Reynosa in Tamaulipas. This subregion had a combined population of approximately 1.36 million in 1990 and grew to 1.90 million in 2000, reflecting a combined growth rate of approximately 39% (see Table 2). Part of this subregion, the McAllen-Edinburg-Mission Metropolitan Statistical Area (MSA) in Hidalgo County was the fourth fastest growing MSA in the entire United States during the 1990s. If the growth rate in the subregion during the 1990s is projected for the current decade, the population of the area in 2010 would be almost 2.64 million, representing more than 50% of the population of the entire FSR. Assuming a “business as usual” scenario, this growth would result in significantly increased environmental impacts.

Table 1. Population in the Four-state Region, 1980–2000

Country	State	Population ¹			Growth Rates	
		1980	1990	2000	1980–1990	1990–2000
Mexico	Coahuila	348,306	422,165	520,510	21%	23%
	Nuevo León	399,085	558,983	631,400	40%	13%
	Tamaulipas	897,875	1,073,997	1,444,961	20%	35%
	Mexico Subtotal	1,645,266	2,055,145	2,596,871	25%	26%
United States	Texas/U.S. Subtotal	819,732	1,029,094	1,391,200	26%	35%
Regional Total (both countries)		2,464,998	3,084,239	3,988,071	25%	29%

¹ The population data for each state represent the population for those municipios or counties that fall, all or in part, within 100 kilometers of the international border, which is the official definition of the border region. In Coahuila this includes 18 municipios, in Nuevo León 20 municipios, and in Tamaulipas 12 municipios. In Texas this includes 24 counties.

Sources: Municipio de Mexico, Instituto Nacional de Estadística Geografía e Informática, U.S. Census Bureau, Texas Data Center and Office of the State Demographer

Table 2. Population in the Lower Rio Grande Valley

Municipio/County	Population			Growth Rates	
	1980	1990	2000	1980–1990	1990–2000
Matamoros	238,840	303,293	418,141	27%	38%
Río Bravo	83,522	94,009	104,229	13%	11%
Reynosa	211,412	282,667	420,463	34%	49%
Mexican Subtotal	533,774	679,969	942,833	27%	39%
Cameron	209,727	260,120	335,227	24%	29%
Hidalgo	283,323	383,545	569,463	35%	48%
Starr	27,266	40,518	53,597	49%	32%
Texas Subtotal	520,316	684,183	958,287	31%	40%
Total	1,054,090	1,364,152	1,901,120	29%	39%

Sources: The 1980 data for the Mexican municipios come from Municipio de Mexico. The 1990 and 2000 data for the Mexican municipios come from the Instituto Nacional de Estadística Geografía e Informática. Data on Texas counties come from the U.S. Census Bureau, through the Texas Data Center and Office of the State Demographer.

Vehicle Fleets in the Four-state Region

Vehicles are one of the leading sources of emissions, and therefore tracking the growth in their numbers can be informative. Table 3 shows the growth in the number of vehicles in the Mexican portion of the FSR. If these data are compared with the population data in Table 1, it can be seen that the number of vehicles has been growing at a significantly higher rate than the population. In the Mexican states, the fleet grew approximately 88% from 1980 to 1990 and then 41% from 1990 to 2000, compared to 25% and 26% growth rates for the population in those two decades. Vehicle data are not available for the counties in Texas prior to 1996, but Table 4 offers the data for 1996 and 2000. The four-year growth rate in vehicles appears to approximate roughly the population growth.

Table 3. Number of Vehicles in the Mexican Municipios of the Four-state Region, 1980–2000

State in Mexico	Number of Vehicles			Growth Rates	
	1980	1990	2000	1980–1990	1990–2000
Coahuila	31,632	90,717	92,270	187%	17%
Nuevo León	3,337	7,660	34,763	130%	54%
Tamaulipas	110,161	182,623	314,452	66%	72%
Tamaulipas (other municipios in region)	54,240	94,769	179,572	75%	89%
Total for Mexican Portion of Region	199,370	375,769	528,787	88%	41%

Source: Instituto Nacional de Estadística Geografía e Informática

Table 4. Number of Vehicles in the Texas Counties of the Four-state Region, 1996–2000

Portion of Four-State Region	Number of Registered Vehicles	
	FY 90196	FY 2000
Lower Rio Grande Valley	434,470	506,402
Rest of Texas in Region	268,780	300,744
Total	703,250	807,146

Source: Texas Department of Transportation, Vehicle Titles and Registration Division

Tables 3 and 4 do not include information on the average age of vehicles. Vehicles in use in Mexico are comparatively old—it has been estimated that more than half are more than 10 years old. There is a large market in Mexico for older used cars from the United States. These vehicles are poorly maintained, and their emissions are considerably higher than emissions from newer and better-maintained vehicles.

Cross-border Truck Traffic

Table 5 shows the number of northbound truck crossings in nine of the 11 Texas ports of entry in the FSR for the period from 1996 to 2004 (data on two additional ports in Harlingen and McAllen were not available for several of those years). Overall, the number of truck crossings at these nine ports increased by approximately 52% from 1996 to 2004. The busiest crossing was Laredo-Nuevo Laredo, with nearly 1.4 million trucks in 2004. The crossings at this port of entry increased by nearly 36% in this period. The second-busiest port of entry in the region, and fastest growing, was Pharr, with 450,000 trucks passing through (the few data available for Harlingen and McAllen show that neither of those ports had numbers near the levels experienced in Laredo, Pharr, and Brownsville). Several other ports of entry saw crossings increase from 50% to 180% in the same period, but four ports—Falcon Heights, Progreso, and Roma—actually experienced decreases because traffic moved to other crossings with better facilities.

Indications are that international trade under NAFTA—and therefore diesel truck traffic—will continue to increase over time (decreases were experienced at a majority of the ports in 2003 and 2004 because of the economic downturn). However, the potential for further harm to air quality is expected to be largely mitigated by new U.S. regulations on diesel engine emissions, which will be being phased in beginning in 2007 (EPA 2005).

Industrial, Commercial, and Agricultural Activities in Subregions

Economic activities vary along the FSR border area. In the western portion of the region—in the border area with Coahuila—the main border crossing (and therefore the principal traffic) is between Piedras Negras and Eagle Pass. Agricultural activities in this sub-region include the production of wheat, corn, forage, and pecans. Livestock activities are also important, including cattle, goat, pig, and lamb breeding. The chief industrial activities are assembly of machinery and electronics, the Carbon I and II coal-fired power

Table 5. Northbound Truck Crossings at Selected Ports of Entry on the Texas Border with Mexico, 1996–2004

Location of Crossing ¹	Annual Number of Crossings ²					Growth Rate 1996–2004
	1996	1998	2000	2002	2004	
Brownsville	207,564	275,661	214,816	200,444	186,947	-10%
Del Rio	40,720	53,623	61,228	72,039	64,061	57%
Eagle Pass	57,569	90,822	106,892	89,856	100,100	74%
Falcon Heights	499	397	452	353	103	-79%
Laredo	1,015,905	1,352,198	1,449,873	1,441,653	1,379,760	36%
Pharr	113,194	262,693	374,150	390,282	454,351	301%
Progreso	23,521	15,499	12,001	23,886	23,064	98%
Rio Grande	14,403	17,871	24,065	26,330	40,815	183%
Roma	12,254	13,501	12,824	9,600	8,407	69%
Total	1,485,629	2,082,265	2,256,301	2,254,443	2,257,608	52%

¹ Two ports of entry—Harlingen and McAllen—are not included because several years of data are not available. The data that are available indicate that neither of these two ports would be in the top three in terms of volume of traffic.

² These numbers represent 2- to 6-Axle Loaded and Unloaded Commercial Vehicles

Source: Texas A&M International University, Texas Center for Border Economic and Enterprise Development

plants near Piedras Negras, and steel companies. Coal and natural gas are being extracted in the area to supply energy for the different activities (Gobierno del Estado de Coahuila de Zaragoza 2005).

The border between Nuevo León and Texas is only about 20 km long, although it includes the Colombia bridge and border crossing, where the traffic is mainly heavy diesel trucks crossing the border in both directions. There are small towns in this sub-region in both Texas and Nuevo León and various forms of agricultural activity. The large metropolitan area and industrial center of Monterrey is outside the 100 km definition of the border region, but still relatively close (within 200 km of the border). Its many sources of emissions may have an impact on air quality in the region, depending on the meteorological conditions on any particular day, including the prevailing winds.

The Tamaulipas-Texas area of the region is home to numerous economic activities. Population on the Mexican side is concentrated mainly in the cities of Nuevo Laredo, Reynosa, Río Bravo, and Matamoros. In Tamaulipas, international border crossings exist with the Texas cities of Laredo, Roma, Rio Grande, Hidalgo, Pharr, Progreso, Harlingen, and Brownsville. In the Laredo-Nuevo Laredo area, traffic from international trade is the leading activity. Commercial activities connected to trade, such as custom brokerage and warehousing, are also important in the area.

The eastern part of that Tamaulipas-Texas border area—Texas's Lower Rio Grand Valley (LRGV) and its sister cities—has agricultural and commercial activities in both countries. The main crops include green peppers, tomatoes, squash, cantaloupe, watermelons, grain sorghum, broom sorghum, peas, green beans, corn, fodder sorghum, okra, broccoli, pinto beans, onions, carrots, and cotton. Cattle breeding is important in the rural areas surrounding the cities (popular breeds include Charolais, Brahman, and Indo-Brazil). Other activities include maquiladoras (more than 250 in Reynosa and Matamoros combined), a refinery in Reynosa, and a power plant in Río Bravo (Gobierno del Estado de Tamaulipas 2005). As noted earlier, this area has more than two-thirds of the population of the FSR and has witnessed increased crossborder traffic (both heavy trucks and light vehicles).

MONITORING AND THE GENERAL STATUS OF URBAN AIR QUALITY IN THE REGION

This section first will summarize the monitoring implemented in the urban areas of the region, with sub-sections treating each side of the border and the generally satisfactory condition of the air quality in those areas. One occasional problem is discussed, related to long-distance transport of ozone into the region. In the following section, several issues of concern will be raised, some of them involving very localized events that pose occasional but very short-term problems and others involving extra-regional phenomena that also affect the area from time to time. Later in the chapter a section will address a different category of air quality concern related to the national parks that are at the northwest end of this region.

Urban Areas on the Texas Side of the Border

The Texas Commission on Environmental Quality (TCEQ) is responsible for monitoring ambient air quality and enforcing the National Ambient Air Quality Standards (NAAQS), which apply to ozone, nitrogen oxides (NO_x), carbon monoxide, sulfur dioxide (SO_2), particulate matter (PM), and lead. The NAAQS and the criteria used to determine attainment of the standards are shown in Tables A and B at the beginning of this monograph. At some sites, TCEQ also monitors volatile organic compounds (VOCs), which are a precursor to ozone and can be a toxic pollutant independent of their relationship to ozone.

In the FSR, TCEQ has air quality monitors in the urban areas where problems could potentially develop—three sites in Laredo and one site each in Brownsville, Mission, Edinburg, Brownsville, and South Padre in the LRGV. Different combinations of pollutants are measured by instruments at each site, as is shown in Table 6. SO_2 and NO_x are not considered potential problems in this region and are not monitored.

Table 6. Urban Monitoring Sites in the Texas Portion of the Four-state Region

County	Name of Site	Pollutants Measured ¹
Webb	Laredo/Border	Ozone, carbon monoxide, PM ₁₀ , PM _{2.5} , lead, and VOCs
	Laredo Bridge	Carbon monoxide, PM ₁₀ , and VOCs
	World Trade Bridge	PM _{2.5}
Hidalgo	Mission	Ozone, PM ₁₀ , PM _{2.5} , and VOCs
	Edinburg	Ozone, PM _{2.5} , and VOCs
Cameron	Brownsville	Ozone, carbon monoxide, PM ₁₀ , PM _{2.5} , and VOCs
	South Padre	Ozone

¹ With respect to PM₁₀, PM_{2.5}, and VOCs, there are both “sampler” monitors that measure samples every few days and “continuous” monitors that measure concentrations all the time. Different sites have different configurations of these monitors types.

Source: Texas Commission on Environmental Quality

Measured concentrations of the regulated pollutants in this region have not violated any of the standards. The principle reason for this positive condition is that the prevailing winds, generally from the Gulf of Mexico, disperse the various emissions that are generated locally and do not allow them to stagnate in the urban areas.

On two occasions in the LRGV in the first half of this decade (in September 2001 in Mission and in September 2004 in Brownsville), instruments measured eight-hour ozone averages of 85 parts per billion (ppb) and 86 ppb, respectively. As can be seen in Table B at the beginning of this monograph, a violation of the U.S. standard occurs when the three-year average of the fourth highest value for each year exceeds 85 ppb. Neither of the sites in Mission or Brownsville has exceeded even 75 ppb for any three-year average, but those two episodes prompted analyses by TCEQ.

The explanation of those events raises the issue of long-distance transport of ozone. TCEQ estimates that ozone precursors generated locally in the LRGV are capable of creating concentrations of ozone

not much greater than 20 ppb. Additionally, normal winds and the time it takes for the precursors to interact chemically to produce ozone then cause those locally generated peaks to actually occur 20 miles to 40 miles downwind. At the same time, with prevailing winds from the southeast, ozone levels being transported into the area are typically no higher than about 10 ppb to 30 ppb. Thus, worst-case impacts with southeast winds should be no more than approximately 30 ppb to 50 ppb in areas 20 miles to 40 miles to the northwest of the main urban populations.

Several times a year, however, winds come from the northeast, which can bring pollution from the Houston-Galveston and Beaumont-Port Arthur areas of Texas, as well as from Baton Rouge, Louisiana, and much of the Midwestern United States. TCEQ analysts believe these imported levels of ozone can reach as high as 70 ppb to 80 ppb. On the rare days when wind speeds suddenly decrease significantly in the LRGV, allowing local and imported ozone to combine and stagnate, concentrations over 85 ppb can occur. It is possible that local Mexican sources, such as the Petrol os Mexicanos (Pemex) refinery in Reynosa, could also contribute to elevated ozone readings.

Monitoring on the Mexican Side

So far, monitoring on the Mexican side of the border in this region has been limited to PM₁₀ (particulate matter with a diameter of 10 microns or less). In Tamaulipas, there are four monitoring stations in Matamoros, four in Reynosa, and four in Nuevo Laredo. This monitoring network started in the mid-1990s, but monitoring was not conducted on a regular basis until 2002 in Nuevo Laredo and more recently in Matamoros and Reynosa. The stations take 24-hour samples every six days.

Results of the sampling in this sub-region have not indicated problems during the periods monitored, except for a one-time high reading that occurred at a monitor at the Reynosa-Hidalgo border crossing.

Sources of pollution identified in or near these urban areas include urban dust, vehicle emissions, burning of waste, and biomass (including agricultural) burning. A photochemical model was

used to study the dynamics of pollutants. The model predicted that ozone formation (a result of the interaction of NO_x and VOCs under the influence of sunlight) would usually peak west of the McAllen-Hidalgo-Reynosa border region due to the prevailing winds from the Gulf of Mexico (Mejía, et al. 2003).

Although the sub-region has experienced only isolated problems, the fast-growing population and the increase in the vehicle fleet and crossborder commercial traffic could have a long-term effect on air quality in the LRGV, especially when combined with long-distance transport of pollution into the area.

In the Coahuila portion of the region to the northwest, PM_{10} was monitored at four sites in Acuña and four sites in Piedras Negras for one month in 2003 and in 2004. A mobile unit monitored one site at a time. The data collected did not show any violations of the Mexican standard.

AIR QUALITY CONCERNS

Although there have not been any violations of national ambient standards in the FSR, local citizens have several concerns. These concerns are in three general categories: air quality-related events that occur irregularly and are the result of locally generated problems; seasonal events that result from the long-distance transport of PM; and the unknown potential for long-term impact from the nearby urban metropolis of Monterrey. This section briefly reviews various phenomena that fall into those categories.

Irregular Local Smoke Events

Smoke events caused by landfill fires or other burning occur each year in the LRGV. In the winter of 2004–2005, for instance, the region experienced four such events:

1. For more than a week, beginning on December 19, 2004, a fire at a landfill in Matamoros flared, was partially halted, and flared again, causing respiratory problems not only in that city but also across the border in Brownsville. Hourly

average concentrations of PM_{10} in Brownsville peaked at 9 a.m. on December 20 at 159 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$).

2. A landfill fire in Harlingen lasted for a week, from December 23 through December 29. There is no PM_{10} monitor in Harlingen, so local concentrations were unknown. Smoke from this fire may have had a marginal effect on concentrations in Brownsville, overlapping with the Matamoros fire.
3. For a couple days in late January, another landfill fire in Matamoros caused similar problems, with PM_{10} hourly averages peaking in Brownsville at 1 p.m. on January 26 at 222 $\mu\text{g}/\text{m}^3$.
4. In early March 2005, smoke coming from Reynosa for a few hours was ascribed to two sources—a fire at an illegal dump and the burning of wastes at a Pemex plant. The hourly average PM_{10} concentration at 8 a.m. on March 10 was 293 $\mu\text{g}/\text{m}^3$ at the monitor in Mission.

Burning of Field Trash at Sugarcane Plantations

Sugarcane is one of the principal agricultural crops grown on the U.S. side of the border in the LRGV. Organic residue in the fields (referred to as field trash) requires disposal both pre- and post-harvest. The current practice is to burn the field trash. TCEQ has outdoor burning rules, which include guidance that burns should take place only when wind conditions will move the smoke and ash away from populated areas. If property owners in Texas complain about fly ash landing on their property when a burn occurs, the sugar mill owner is obligated to respond and clean up the ash. Despite these rules, TCEQ receives occasional inquiries and complaints from both sides of the border.

On the Mexican side, agricultural burnings also are common. Although there is an Official Mexican Regulation (NOM-015-SEMARNAT/SAGAR 1997) for the burning of agricultural fields, it is usually not followed by local farmers. In Mexico, the sugar growers are typically low-income and for this reason the government is hesitant to impose fines. A social problem thus becomes an environmental problem. The burnings occur without supervision by the

authorities, and the possible environmental and health consequences of this problem have not been evaluated. However, efforts are underway to assess the possible impacts of these burnings on air quality and human exposure.

Exposure to Emissions from Traffic at Border Crossings

The potential problem of emissions from the numerous vehicles (especially diesel trucks) at border crossings is exacerbated by the fact that long lines frequently result in vehicles idling for extended periods. This has caused concern about the possible exposure of people working at the crossings, such as immigration and customs officers, to various types of particulates and VOCs. Peaks of PM₁₀ have been measured by Mexican monitors at border crossings.

A one-time exceedance of the U.S. carbon monoxide standard was measured at the Laredo Bridge by a TCEQ monitor in December 1998, but this appears to have been the result of a meteorological anomaly. Similar concentrations have not been repeated, and the completion of an additional bridge in Laredo the following year reduced whatever localized potential for a problem might have existed.

Agricultural Activities

Agricultural activities are important in the economy of the FSR, in particular in the LRGV. With all the different chemicals involved in these activities, there is concern about the use of pesticides. Studies have been conducted to evaluate potential links between residents' health and environmental pollution (Akland, et al. 1997; Mukerjee, et al. 1997). The results of these studies provide preliminary data on levels, sources, and pathways of exposure and levels of pesticides and polycyclic aromatic hydrocarbons (PAHs). The studies have not yet found any high level of exposure to pesticides on the region.

Transport of Pollutants from Elsewhere in Texas or Northeast Mexico

As described earlier, ozone sometimes travels south from the Houston area to the Lower Rio Grande Valley and can, under meteorological conditions that are relatively rare, create unhealthy air quality conditions.

Another source of middle-distance transport is the Monterrey Metropolitan Area (MMA), which is approximately 120 km from the border and therefore can have a significant impact on the region when the winds are blowing toward the north. Air quality in Monterrey is among the worst in Mexico. Since 1993 the MMA has had five monitoring stations that continuously measure concentrations of PM₁₀, SO₂, NO_x, carbon monoxide, and ozone. In 2003 a monitor for PM_{2.5} (particulate matter with a diameter of 2.5 microns or less) was added. The data have shown numerous violations of two Mexican air quality standards in Monterrey. The one-hour ozone standard has been violated from 10 days to 30 days each year. The 24-hour PM₁₀ standard has been violated from 30 days to 90 days each year. Additionally, since 1993 the standard for annual average concentration of PM₁₀ has been exceeded each year in the MMA. Since 1999, the concentration of PM₁₀ has been increasing, and in some zones of the MMA the annual average has reached values more than twice the standard, posing significant health risks to the local population. Studies and initiatives are underway to better characterize the problem and reduce emissions from various sources.

Transport from More Distant Sources—Smoke and Dust

An example of pollution carried into the region from more distant sources is the smoke that comes from agricultural burning and forest fires in southeastern Mexico and Central America. This typically occurs in an April-through-May timeframe, and can come sporadically during those periods. Because of the pathway and intensity of the smoke, it is experienced across a broad geographic area that extends from the fires themselves to areas several hundred miles north of the FSR.

The worst such episode in the FSR in the past decade occurred in 1998, when one-hour averages of $\text{PM}_{2.5}$ (PM with an aerodynamic diameter of 2.5 microns or less) were above $100 \mu\text{g}/\text{m}^3$ at the monitor in Brownsville on several occasions during that burning season. Peak hourly averages in similar events in 2000 and 2003 reached levels of $66.2 \mu\text{g}/\text{m}^3$ and $64.6 \mu\text{g}/\text{m}^3$, respectively (TCEQ 2006). Such averages create very short-term unhealthy and upsetting conditions, but fortunately they seldom result in 24-hour averages in this region that exceed the federal standard and that would be viewed as serious public health concerns. Higher averages are experienced, of course, in Mexico to the south of the FSR.

The FSR encounters an additional seasonal air quality problem, but one not caused by any events in the hemisphere. In several episodes between early June and early August each year, sand whipped into the atmosphere by winds over the Saharan Desert and the sub-Sahara in northwest Africa passes over a lengthy swath of coast, extending from Port Arthur, Texas, to Veracruz, Mexico, (and much of the Yucatán Peninsula) after a one- to two-week journey across the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico.

Although the north-south extent of this phenomenon is relatively large, and measurable amounts of the dust are carried several hundred miles inland, the peak measurements of PM are usually identified in the U.S.-Mexican border region near the Gulf coast. The stronger episodes reach the level of “moderate” on the U.S. Environmental Protection Agency’s (EPA) Air Quality Index (AQI) scale. The only more serious event since continuous monitoring of $\text{PM}_{2.5}$ began in 1999 was an episode that lasted from June 17 through June 20 in 2004 and registered at the level of “unhealthy for sensitive groups.” Daily average concentrations peaked at $46.6 \mu\text{g}/\text{m}^3$ on June 18 in Brownsville (TCEQ 2006).

VISIBILITY AT BIG BEND NATIONAL PARK

In addition to the regulations explicitly related to the criteria pollutants discussed thus far in this chapter, the U.S. Clean Air Act includes special protection for national parks with respect to another ambient air problem—visibility. In the FSR, concern exists about degraded visibility at Big Bend National Park in far West

Texas. A similar problem likely exists across the border from Big Bend in Mexico's Maderas del Carmen National Park, but Mexican law does not include visibility protections and the phenomenon is not tracked there.

In the mid-1990s, EPA and the U.S. National Park Service began working with TCEQ on designing and implementing a study of the haze in Big Bend. Researchers released tracers at selected sites both in eastern Texas and on the U.S. side of the border with Mexico and engaged in intensive monitoring in 1999. Then four years was spent in performing analysis and modeling in an attempt to identify sources of the problem.

The final report, which was issued in September 2004, confirmed what was known generally about haze—that the main cause was fine particulate matter and, in the case of Big Bend, chiefly sulfates formed from SO_2 , which was determined to be 55% of the cause. On the days of least visibility, the study concluded, “sulfates from states to the east and north of Texas were responsible for approximately 22% of the man-made haze at the park.” On those days, approximately 16% of the haze originated in Mexico (presumably at two coal-fired electricity plants in Coahuila) and 11% originated within Texas (U.S. National Park Service 2004).

In 1999 EPA issued “Regional Haze Regulations” to underscore the importance of long-distance transport of the pollutants that reduce visibility (EPA 1999). The regulations encouraged, and provided a small amount of funding for, multi-state cooperation. Texas is working with several other U.S. states on developing a regional strategy. Additionally, because the data were collected at Big Bend in 1999, a new Texas law has required “grandfathered” coal-fired power plants to reduce their emissions of SO_2 . In March 2005 EPA announced the Clean Air Interstate Rule (CAIR), which builds upon a previous a cap-and-trade regime for emissions of SO_2 and NO_x in eastern U.S. states (all the states to the northeast of Texas) (EPA 2005a). Taking a state-by-state approach that will lower each state's allowable emissions, CAIR is expected to result in a 60% reduction in overall SO_2 by 2020 (compared to 2003) and another 7% in subsequent years. Taken together, these Texas and federal actions should have a measurable effect on haze in Big Bend.

LOCAL AIR POLLUTION INITIATIVES

The Border 2012 U.S.-Mexico Environmental Program

The mission of the binational Border 2012 Program is to protect the environment and public health of the U.S.-Mexican border region, consistent with the principles of sustainable development. The program is an agreement among EPA, the Mexican Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), the eleven border states (six Mexican and four U.S.), and the U.S. border tribes. The program covers goals for air, land, water, health, exposure, and environmental performance. In the case of air, the goal is to reduce pollution with the following objective and interim objectives:

Objective: By 2012 or sooner, reduce air emissions as much as possible toward attainment of respective national ambient air quality standards, and reduce exposure in the border region, as supported by the following interim objectives:

Interim Objective 1. By 2003, define baseline and alternative scenarios for emissions reductions along the border, and their impacts on air quality and human exposure.

Interim Objective 2. By 2004, based on the results of Interim Objective 1, define specific emission reduction strategies, and air quality and exposure objectives to be achieved by 2012.

Within the FSR, as defined by the 100 km zone on each side of the border, the standards for regulated pollutants are being met in both countries, which satisfies the principal Border 2012 objective. But because of the potential impact of growth in the region interacting with imported pollution, a series of workshops and public consultations led to the identification of the following priorities related to air pollution in the FSR:

- Improved collection and cross-border sharing of air emissions inventories
- Expanded collection of emission-related data, to include toxics, particularly from refineries in Monterrey and Reynosa

- Determination of the air pollutants posing the greatest risks in specific geographic regions, and the environmental projects that will yield the greatest benefits for reducing health risks
- Development of smoke-reduction strategies and reduction of particulate emissions, such as from agricultural burning, trash burning, road dust, tire pile fires, and similar sources
- Coordinated reduction of emissions from diesel engines and other high-emitting vehicles

Emission Inventories

Emission inventories provide estimates of the total volumes of pollutant emissions in a geographic area, and also provide disaggregated data on distinct categories of sources. They are powerful tools for evaluating the status and trends of estimated emissions in urban areas or regions of interest. This information is used to develop and evaluate air pollution control strategies. Although air quality has been good in the FSR—with the exception of occasional local episodes—it is still important to develop emission inventories for the region. Tables 7 and 8 present recent aggregated emission inventories for the Mexican municipios on the border in the FSR and for the Texas counties in the LRGV, respectively.

Table 7 shows that the regulated pollutants emitted in the largest volumes on the Mexican side are NO_x and SO₂ (ambient concentrations of VOCs and ammonia are not regulated). The *municipio* of Nava, Coahuila, contributes the largest proportion of those pollutants in the FSR, due to the presence of the Carbon I and II coal-fired power plants. The three Tamaulipas *municipios* located in the LRGV (Reynosa, Rio Bravo, and Matamoros) have the next highest contribution, followed by the *municipio* of Nuevo Laredo. Río Bravo shows high NO_x and SO₂ emissions due to the presence of a power plant. It is important to note that the emissions shown in Table 7 were calculated under certain assumptions that need to be re-evaluated to obtain better estimates.

Table 8 shows the emissions in the Texas counties in the LRGV. Reflecting their relative populations, Hidalgo County contributes the largest volume of emissions, followed by Cameron and Starr. Willacy produces the smallest contribution.

Table 7. Emission Inventory for the Mexican *Municipios* Bordering Texas in the Four-state Region, 1999

Mexican State	Emissions (in million grams per year)							
	Municipio	NO _x	SO _x	CO	PM ₁₀	PM _{2.5}	VOCs	Ammonia
Coahuila	Acuña	5,258	814	5,948	5,445	1,019	28,532	1,248
	Guerrero	1,595	21	167	138	46	4,219	783
	Hidalgo	1,024	20	141	273	75	3,141	385
	Jiménez	2,988	156	1,418	644	231	4,226	605
	Nava	104,626	151,139	3,104	9,314	8,233	3,271	337
	Ocampo	7,742	158	1,365	796	227	84,368	855
	Piedras Negras	1,625	590	6,722	6,209	1,172	5,720	330
	Zaragoza	3,786	30	455	631	119	29,872	1,416
Nuevo León	Anáhuac	3,216	117	1,183	1,003	235	8,870	1,383
Tamaulipas	Camargo	654	27	582	857	165	1,610	278
	G. Diaz Ordaz	259	12	415	835	144	858	148
	Guerrero	1,351	25	243	250	65	8,657	892
	Mier	414	7	272	327	55	1,028	452
	Miguel Alemán	657	31	665	871	156	987	269
	Nuevo Laredo	5,251	467	20,468	11,459	2,495	13,747	702
	Ocampo	727	17	1,740	881	278	40,842	670

Table 7. continued

Mexican State	Emissions (in million grams per year)							
	Municipio	NO _x	SO _x	CO	PM ₁₀	PM _{2.5}	VOCs	Ammonia
Tamaulipas	LRGV ¹							
	Matamoros	6,979	1,162	26,137	15,938	3,744	12,352	1,504
	Reynosa	11,974	1,160	27,937	15,247	3,468	14,180	1,129
	Río Bravo	11,699	17,270	3,772	6,594	2,238	2,817	345
	Total LRGV	30,652	19,592	57,846	37,779	9,450	29,349	2,978
Total of Border Municipios		171,825	173,223	102,734	77,712	24,165	269,297	13,731

¹ The eastern portion of the Four-State Region, referred to as the Lower Rio Grande Valley (LRGV) on the Texas side of the border, includes the overwhelming majority of the population in the entire region. On the Mexican side of the border, this sub-region comprises three municipios—Matamoros, Reynosa, and Río Bravo.

Table 8. Emission Inventory for the Texas Counties Bordering Mexico in the Lower Rio Grande Valley, 2002

County	Emissions (in million grams per year)						
	NO _x	SO ₂ ¹	CO	PM ₁₀ ¹	PM _{2.5} ¹	VOCs	Ammonia ²
Cameron	11,105	742	83,917	35,333	6,170	23,871	153,584
Hidalgo	38,418	1,077	134,054	61,279	10,831	37,193	410,763
Starr	13,292	113	19,715	12,141	2,110	18,031	40,153
Willacy	3,793	136	11,395	8,694	1,626	8,347	44,589
Total	66,608	2,068	249,081	117,447	20,737	87,442	649,089

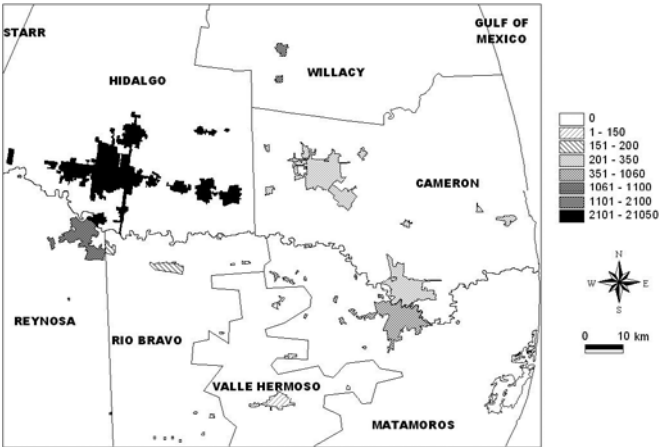
Source: Instituto Tecnológico y de Estudios Superiores de Monterrey and University of Utah

Comparing the data in Table 7 that pertain to the Mexican *municipios* in the LRGV (Matamoros, Río Bravo, and Reynosa) to the Texas LRGV data in Table 8 (ignoring the relatively insignificant three-year difference in the data source for the sake of this analysis) shows that NO_x emissions were 117% higher in the Texas counties than in the Mexican *municipios*. In the case of carbon monoxide, the volume was approximately 330% higher in Texas counties. In the case of SO₂, the emissions in Texas were only about 10% of the emissions in Mexico, while VOCs emissions were 198% higher in Texas. In the case of PM₁₀ and PM_{2.5}, the emissions in the Texas counties of the LRGV were higher than emissions in the Mexican *municipios* by 188% and 119%, respectively. As mentioned, to make a more robust comparison, it will be necessary to obtain better estimates of the emissions inventories for the *municipios*. It will also be important to update the data on both sides of the border over time in order to evaluate the possible implications of various trends.

When disaggregated source data are located geographically and diurnal variability is known, analysts can then use source dispersion models and knowledge of atmospheric chemistry to predict air quality under specified conditions. As an example of such geographical data, Figures 1 through 5 show the geographical distribution of NO_x emissions for area, natural (biogenic), mobile nonroad, mobile on-road, and point sources, respectively. The plots were made using the

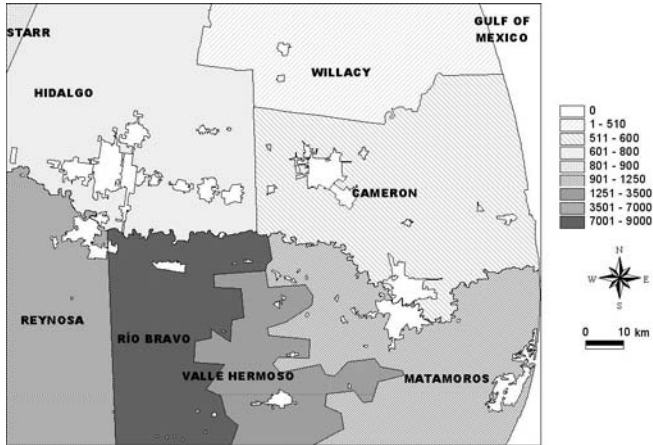
same data on NO_x emissions that were rolled up into the aggregates shown in Tables 7 and 8, and were prepared as part of a project being implemented jointly by the Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM) and the University of Utah.

Figure 1. NO_x Emissions from Area Sources in the Lower Rio Grande Valley



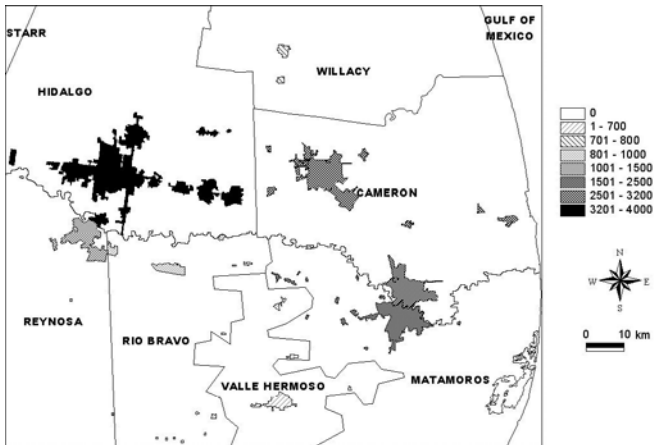
Source: 1999 National Emission Inventory for Mexico, ITESM, and the University of Utah

Figure 2. NO_x Emissions from Natural/Biogenic Sources in the Lower Rio Grande Valley



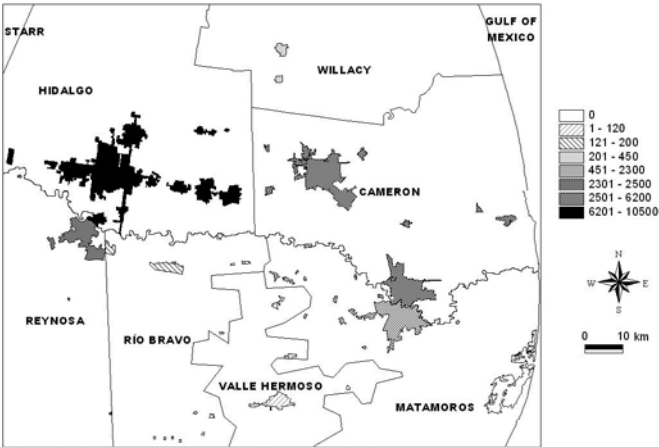
Source: 1999 National Emission Inventory for Mexico, ITESM, and the University of Utah

Figure 3. NO_x Emissions from Mobile Nonroad Sources in the Lower Rio Grande Valley



Source: 1999 National Emission Inventory for Mexico, ITESM, and the University of Utah

Figure 4. NO_x Emissions from Mobile On-Road Sources in the Lower Rio Grande Valley



Source: 1999 National Emission Inventory for Mexico, ITESM, and the University of Utah

Figure 5. NO_x Emissions from Point Sources in the Lower Rio Grande Valley



Source: 1999 National Emission Inventory for Mexico, ITESM, and the University of Utah

In the figures, shading and patterns distinguish different levels of emissions, so urban sources can be easily identified in Figures 1, 3, 4, and 5 (for Figure 2, natural or biogenic sources of NO_x emissions were estimated for the non-urban areas). The U.S. counties have larger NO_x emissions than the Mexican *municipios* in all source categories except the natural/biogenic sources. As mentioned, the Mexican Emission Inventory was estimated with certain assumptions and limitations. If reliable strategies to control air pollution are to be implemented, it is necessary to review those assumptions and obtain an updated emission inventory for the LRGV.

Meteorological, topographical, and land use data are necessary to develop better air quality studies in the region and are available. Data from monitoring sites in the urban areas can be used to validate regional air quality models. On the Mexican side, there is a lack of continuous (rather than sampling) monitoring equipment for PM in the border region itself. Continuous monitoring is performed in Monterrey, and because of that urban center's size and proximity, its emissions may very well play a role in the region's air quality. Analysis by the TCEQ, as described earlier, has already shown that long-distance transport of ozone from Houston and other areas to the northeast is an important factor in the LRGV when winds blow from that direction.

Other Initiatives

In recent years, several initiatives have helped—directly or indirectly—reduce pollution in the FSR, compared with the no-action scenario. Because the FSR is an attainment area, however, resources have not been dedicated to assessing the results of those initiatives.

One type of action that likely has had a beneficial effect has been the modernization of border-crossing facilities and the construction of new such facilities. This has reduced the average waiting time at the border, although in some cases the increase in the number of trucks over time, combined with the security precautions enacted since 2001, may be overwhelming that effect. One example of a net gain occurred with the opening of the World Trade Bridge near in

Laredo, which resulted in lower concentrations of carbon monoxide at the Laredo Bridge (Texas Natural Resource Conservation Commission 2002).

New regulations related to diesel engine emissions and the use of ultra-low-sulfur diesel fuel will begin a phase-in later in 2006 in the United States, and over time this will reduce diesel emissions significantly (EPA 2005b).

In Mexico, technologies in new vehicles have generally improved and are similar to those used in the United States. Also, fuel quality has improved. Leaded gasoline is no longer sold, and low-sulfur diesel fuel is in use, and the Mexican government has declared its intention to introduce ultra-low-sulfur fuel this decade. Also, emission inventories will improve in Mexico as a result of new rules requiring large industries in Mexico to report their emissions in the Annual Operation Report (Cédula de Operación Annual, COA).

Economic incentives are available in both countries to stimulate the introduction of air pollution control and energy-efficiency technologies in industries. There are also initiatives for using alternative fuels, in particular compressed natural gas (CNG), in residential areas and for transportation and industry (the City of Laredo has used U.S. government subsidies to purchase CNG buses). However, the recent high prices of CNG and its availability have at least temporarily slowed new plans for the use of this fuel.

Environmental education has been introduced in official educational programs in Mexico. The government, industry, and service sectors have adopted programs to improve the environment and their own environmental performance. People working in various sectors have the opportunity to attend professional development courses on environmental pollution, its impact on health, and the benefits of pollution prevention.

CONCLUSIONS AND RECOMMENDATIONS

Air quality data from monitoring stations in the FSR indicate that concentrations of measured pollutants in the region are in compliance with standards of both Mexico and the United States. However, there are local, short-term air quality events of an irregular or seasonal nature, mostly in the LRGV, that deserve attention. Also,

some episodes have occurred due to the long-range transport of pollutants that have affected the FSR or emissions of the FSR that have affected other regions.

The population and vehicle fleet in the FSR are growing fast. Depending partly on the development of vehicular technologies, population and economic growth may cause an increase in emissions in the region that, to some degree, compromise air quality. Therefore, it is desirable to maintain current initiatives that reduce emissions and public health risks—in particular the risks to people exposed because of their jobs or other reasons to emissions from heavy traffic, especially diesel trucks. As better fuels become available in the United States and Mexico, the risk of exposure to fuel-related pollutants may not increase.

It is important to maintain and regularly update databases on population, vehicle fleets, truck crossings, and emissions in order to enable periodic assessments of the situation. With this and other related information and evolving analytical techniques, emission inventories can be calculated with the participation of all interested stakeholders. The transboundary pollution, and regional impacts.

ENDNOTE

This chapter includes data from a project being carried out by the University of Utah and the Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM), with the support of a National Science Foundation-Consejo Nacional de Ciencia y Tecnología (CONACyT) program. The authors gratefully acknowledge their support. Alejandra Estrada also thanks CONACyT and ITESM for financial support during her Master's studies at ITESM.

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V

Health Effects of Air Pollution in the U.S.-Mexican Border Region

Shelley Scalzo

ABSTRACT

Of the environmental problems researchers have addressed in the U.S.-Mexican border region, none appear more complicated than the problem of air quality. An understanding of atmospheric chemistry and long-distance (including cross-border) transport and an identification of source/receptor relationships are slowly unfolding in the hands of scientists and policymakers. Coupling air quality with the associated health effects transforms the problem from challenging to urgent.

The purpose of this chapter is to examine and link both criteria pollutants and hazardous air pollutants in the U.S.-Mexican border region with their associated health risks. While the chapter examines pollution sources throughout the border zone as defined by the La Paz Agreement, it focuses mostly on transboundary and boundary-related (i.e., ports of entry) pollutants. It is not intended to be an exhaustive study of either the border region's air quality or the health consequences of it, but rather to serve as a snapshot of selected pollutants from just a few locations along the border. It is intended to paint a picture showing that the air chemistry mixture in this region is a unique amalgam with contributions from both

countries, not a mere extension of either. This chapter is an overview of the type and magnitude of the health hazard and highlights insights gained from the decade-long examination of air quality and health effects along the border that has been supported by the Southwest Consortium for Environmental Research and Policy (SCERP).

Of the criteria pollutants identified by the Clean Air Act, ozone and particulate matter (PM) remain a serious threat to health in many parts of the U.S.-Mexican border region. This chapter uses the experience of San Diego, California, and Tijuana, Baja California, to illustrate the magnitude of health effects associated with ozone pollution. PM is addressed by examining research and conditions present in the Imperial-Mexicali Valley. This region has the second highest weighted annual mean concentration of PM_{10} in the United States. Between 1998 and 2000, Imperial County had the highest age-adjusted asthma hospital discharge rate in California.

This chapter also examines the problem of indoor air quality in the border region. SCERP research has identified the incidence of indoor carbon monoxide (CO) in Ciudad Juárez, Chihuahua. A comparison of this rate, as well as risk factors associated with CO poisoning, to rates and risk factors in the United States reveals an alarming problem in Ciudad Juárez.

Hazardous air pollutants (HAPs) are of concern to researchers because a growing body of evidence links them to health outcomes such as cancer and reproductive harm. Potential for exposure to HAPs is significant along the U.S.-Mexican border. This chapter specifically addresses the effects of polycyclic aromatic hydrocarbons, mercury, and tungsten. Each of these types of HAPs has different sources unique to the lifestyles and industrial activities that occur along the U.S.-Mexican border.

Efectos en la Salud de la Contaminación del Aire en la Región Fronteriza de México y los Estados Unidos

Shelley Scalzo

RESUMEN

De los problemas ambientales que los investigadores han tratado en la región fronteriza de México-Estados Unidos, ninguno parece ser más complicado que el problema de la calidad del aire. El entendimiento de la química atmosférica y del transporte a largas distancias (incluso el transfronterizo) y la identificación de las relaciones entre las fuentes y los receptores se desarrollan lentamente en las manos de los científicos y de los responsables de elaborar políticas. La calidad del aire aunada a los efectos asociados con la salud, convierte al problema de ser un reto a ser urgente.

Los objetivos de este capítulo son analizar y vincular tanto a los contaminantes criterio como a los contaminantes atmosféricos peligrosos en la región fronteriza de México y los Estados Unidos con sus correspondientes riesgos para la salud. Aunque el capítulo examina las fuentes de la contaminación en toda la zona fronteriza—como ésta se define en el Acuerdo de La Paz—se enfoca principalmente en los contaminantes transfronterizos o aquellos relacionados con la frontera (es decir, los puertos de entrada). Este apartado no pretende ser un estudio exhaustivo ya sea de la calidad del aire de la región fronteriza o de las consecuencias de ésta en la salud. Más bien pretende presentar una breve perspectiva de ciertos contaminantes de sólo unos pocos lugares a lo largo de la frontera. La intención es dibujar una imagen que muestre que la mezcla química atmosférica en esta región es una amalgama singular con aportaciones de ambos países, y no una simple extensión de cualquiera de los dos. Este capítulo es una sinopsis del tipo y

magnitud de los peligros para la salud. Resalta la perspicacia adquirida en una década de análisis de la calidad del aire y los efectos en la salud a lo largo de la frontera que ha contado con el apoyo del Consorcio de Investigación y Política Ambiental del Suroeste (CIPAS).

Entre los contaminantes criterio identificados por el La Ley de Aire Limpio, el ozono y el materia particulada siguen siendo una seria amenaza a la salud en numerosas partes de la región fronteriza de México-Estados Unidos. Este capítulo utiliza la experiencia de Tijuana, Baja California y San Diego, California para ilustrar la magnitud de los efectos en la salud asociados con la contaminación de ozono. El PM es abordado al examinar las investigaciones y condiciones presentes en el Valle Mexicali-Imperial. Esta región tiene la segunda más alta concentración media anual ponderada de PM_{10} en los Estados Unidos. Entre 1998 y 2000, el Condado de Imperial tuvo el índice más alto en California en cuanto a las dadas de altas en los hospitales de pacientes con asma de acorde a su edad.

Este apartado también examina el problema de la calidad del aire interior en la región fronteriza. Las investigaciones del CIPAS ha identificado la incidencia de monóxido de carbono en los interiores en Ciudad Juárez, Chihuahua. Una comparación de este índice, así como los factores de riesgo asociados con el envenenamiento de CO, con índices y factores de riesgo en los Estados Unidos revela un alarmante problema en Ciudad Juárez.

Los contaminantes peligrosos del aire (HAPs, por sus siglas en inglés) son de preocupación para los investigadores debido a la creciente evidencia que los relaciona con las consecuencias en la salud tales como el cáncer y el daño a la reproducción. El potencial de exposición a los HAPs es significativo a lo largo de la frontera de México-Estados Unidos. Este apartado aborda específicamente los efectos de hidrocarburos aromáticos policíclicos, mercurio y tungsteno. Cada uno de estos tipos de HAPs tiene fuentes diferentes y particulares a los estilos de vida y actividades industriales que ocurren a lo largo de la frontera de México y los Estados Unidos.

INTRODUCTION

In the past two decades, an increasing level of attention has been paid to the U.S.-Mexican border region after a long period of neglect. The movement toward globalization and free trade among nations has shifted the overall perception of the region. Once considered relatively barren and short on resources, the region is now viewed in an entirely different light. Sleepy towns have become bustling metropolitan areas with significant industrial sectors, and border crossings have become critical international economic links. Labor has emerged as the region's leading economic resource, supported by a predicted population growth rate of 23% over the next 10 years (Peach 2003). The unprecedented growth of the region has caused some of its limited natural resources to dwindle into despair and has caused an increase in the production of wastes and threatening emissions. Out of these dismal and undeniable side-effects of rapid growth, degradation of the environment has surfaced as a leading problem in the border region.

Attention drawn to the U.S.-Mexican border is overwhelmingly economic in nature. But the decline of the environment and the rise of related health complications have attracted the interest and efforts of a number of governmental agencies and non-governmental organizations (NGOs), which have targeted the U.S.-Mexican border region for research and assistance with the goal of improving the overall quality of life. In doing so, these organizations have encountered a host of environmental problems tightly wound to economic, political, social, and geographic factors unique to this region.

Of the environmental problems researchers have addressed in the U.S.-Mexican border region, none appear more complicated than the problem of air quality. An understanding of atmospheric chemistry and long-distance (including cross-border) transport and an identification of source/receptor relationships are slowly unfolding in the hands of scientists and policymakers. Coupling air quality with the associated health effects transforms the problem from challenging to urgent.

Researchers at the Southwest Consortium for Environmental Research and Policy (SCERP) have launched a series of studies focusing on air quality and associated health effects. These studies reinforce the complexity of air quality as well as the uniqueness of the U.S.-Mexican border region.

SAN DIEGO-TIJUANA

Air Quality

Ozone is the leading air pollutant of concern in the part of the border region that includes San Diego, California, and Tijuana, Baja California. It is a secondary pollutant formed as sunlight breaks down nitrogen oxides (NO_x) and volatile organic compounds (VOCs, including hydrocarbons), a reaction that occurs readily in San Diego and Tijuana due to the prevalence of sunlight year-round. The major sources of NO_x and VOCs in this region are automobiles and heavy trucks. High densities of these vehicles are located north of San Diego in the South Coast Air Basin (the Los Angeles area). From that air basin, ozone precursors and ozone itself are transported off the coastline during Santa Ana wind conditions, when the normal on-shore wind flow shifts to off-shore. They then are pushed back on shore to the south in San Diego when prevailing on-shore conditions return (Sweedler, et al. 2003).

In 2004, monitoring stations at lower mountain slope areas in eastern San Diego County, such as in the city of Alpine, and coastal stations, such as those in Del Mar and at the Marine Corps' Camp Pendleton, recorded 12 days in which concentrations of ozone exceeded California's stringent standard for one-hour maximum concentration (>0.095 ppm) (San Diego Air Pollution Control District [SDAPCD] 2005). Ozone exceeded the federal one-hour standard (>0.125 ppm) for only one day in 2004 (SDAPCD 2005). In 1997, the U.S. Environmental Protection Agency (EPA) revised the federal one-hour ozone standard to an eight-hour ozone standard (>0.085 ppm), in which an average ozone concentration is calculated for eight hours. This change was needed to protect against longer exposure periods (EPA 1997). There were eight days in which ozone concentrations in San Diego exceeded the eight-hour stan-

dard. Monitoring of ozone peaks over the past 10 years shows an overall decrease in the number of days per year on which there are exceedances of state and federal standards; this is attributed to pollution control efforts (SDAPCD 2004).

In Tijuana, high densities of vehicles are located at border crossings and in industrial areas. Elevated NO_x levels occur in the morning and evening when commuter traffic is peaking. NO_x emitted in the morning is combined with VOCs, and together with energy from sunlight contribute to elevated ozone levels (Sweedler, et al. 2003).

Although San Diego remains a nonattainment area for ozone under both California and federal standards, the area has been moving successfully toward attainment despite growth in population and vehicle use. Control of vehicle emissions is the single most effective strategy in reducing ozone in the San Diego region. An example of an effective strategy is the Carl Moyer Air Quality Standards Attainment Program, which began in 1999. This program provides incentives for replacing engines in heavy-duty diesel trucks and other mobile sources. Although heavy-duty diesel engines account for less than 5% of engines used in mobile sources in California, they have been responsible for 40% of the state's NO_x emissions (California Environmental Protection Agency [CalEPA] 2004). In the first four years, the Carl Moyer Program had a total budget of approximately \$114 million. The California Air Resources Board has estimated that heavy-duty engine projects supported by the Carl Moyer Program in the first four years removed 14 tons of NO_x per day at a cost of \$3,000 per ton statewide (CalEPA 2004).

By removing the leading source of NO_x to the atmosphere through emission-control programs, San Diego has experienced a dramatic reduction in the number of days exceeding California's one-hour ozone standard. The number decreased from 96 days in 1995 to 12 days in 2004.

Across the border in Tijuana-Rosarito, air quality monitoring began in 1995 (EPA 2005). That monitoring program is relatively young compared to programs in California, which began in the late 1970s following the U.S. Clean Air Act. Monitoring of ozone in Tijuana-Rosarito from 1997 to 1998 showed a decline in the percentage of days exceeding the standard for ozone (EPA 2005). Although this trend points toward a positive development, a larger

temporal view is required to assess changes in ozone concentration for the Tijuana region. It has been suggested that modernization of Tijuana's vehicle fleet through emission control equipment will strengthen the decline in ozone concentrations over the coming decades. Such changes will require the support of policy and government to absorb the cost of organizing and implementing effective air pollution controls.

HEALTH

Elevated ozone concentrations are scientifically linked to medical conditions such as reduced respiratory function, eye irritation, and exacerbation of asthma. These conditions lead to mortality, hospital admissions, lost work and school days, and reduced activity days. The National Research Council (NRC) studied the financial impact of revising the one-hour ozone standard (0.12 ppm) to the more protective eight-hour standard (0.08 ppm). The council estimated the United States could save \$491 million per year by avoiding cases of ozone-related mortality, hospital admissions, and treatment of acute respiratory conditions (NRC 2002).

Most of the data supporting the association between ozone exposure and asthma exacerbation are derived from clinical studies (Ostro 1994). Time-based studies may prove more valuable than clinical studies because they indicate adverse effects in specific locations, quantify short-term effects, identify pollutants, and support previously established associations between air pollution and health outcomes (National Research Council 2002). Epidemiological cohorts are recommended for the study of health effects of air pollution, specifically when mortality is the outcome of concern. Cohort studies "provide the most complete estimates of both attributable numbers of deaths and average reductions in life span attributable to air pollution" (NRC 2002).

In 2000, the Behavioral Risk Factor Surveillance System suggested the prevalence of asthma among adults in the United States was 7.5% (Centers for Disease Control and Prevention [CDC] 2004). Adults lost 11.8 million work days in 2002. In addition, some 14.7 million school days were missed by American children ages 15 to 17 (National Center for Health Statistics 2002). In

California alone it was recently estimated that 2,268,300 people suffer from asthma. The prevalence of asthma in California is 8.4%, placing the state among the 10 with the highest asthma prevalence (Henry J. Kaiser Family Foundation 2003). In California, 71.6% of the population lives in an area that does not meet EPA's National Ambient Air Quality Standards for all criteria pollutants, including ozone. California ranks second in the nation with respect to the percentage of people living in counties that exceed one or more National Ambient Air Quality Standard (Seitz 1995).

Despite the reduction in ozone concentrations in San Diego County, the number of hospital discharges for asthma has declined only slightly from 94.4 per 100,000 in 1997 to 83.4 per 100,000 in 2000 (San Diego Association of Governments 2000). This indicates other factors aside from ozone may be influencing the asthma hospitalization rates. Hospital discharge rates (HDR) can be used to derive a broad association between ozone concentration and health outcomes. When looking at the San Diego-Tijuana region, or any cities along the U.S.-Mexican border, it is challenging to distinguish the cause of a specific outcome because other regional factors such as other air pollutants, allergic reactions, smoking, and occupational exposures can induce a similar outcome. Using HDRs captures the number of people who suffered symptoms so severe hospitalization was required; they are perhaps the most vulnerable members of the population. But the HDR will capture only the number of people who seek medical attention at a hospital for ozone-related asthma and omit cases that were not treated by a hospital. It is common in border communities for residents to self-medicate, seek only primary care or emergency room physicians, or not seek medical attention at all, leading to an unquantifiable underestimation of asthma incidence.

A recent study published by the Journal of the American Medical Association (Bell, et al. 2004) revealed an alarming relationship between ozone and mortality. The study measured the short-term effects of ozone on daily death rates and deaths attributed to cardiovascular and respiratory complications. The population was drawn from 95 urban communities in the United States. The study found that mortality increased 0.52% when a 10 parts per billion (ppb) increase in the daily average occurred, 0.64% when a 15 ppb

increase in the eight-hour maximum ozone concentration occurred, and 0.67% for a 20 ppb increase in the daily hourly maximum occurred. Researchers advise that these results underestimate the effect of ozone on mortality. In addition, the study did not address the effects of long term-exposure to ozone. The results of this study can be loosely applied to the border region. In applying these results, it is likely a greater underestimation would exist because of differences between the cities along the U.S.-Mexican border and other U.S. urban centers.

IMPERIAL AND MEXICALI VALLEYS

Air Quality

The Imperial and Mexicali Valleys share similar topographic conditions. The valleys are situated in a closed basin below sea level (Sweedler, et al. 2003). Closed basins and low elevations are notorious for contributing to the formation of an inversion layer that prevents vertical mixing of pollutants. The effect of low-laying basins on atmospheric mixing was first observed in the Los Angeles area during the 1940s and contributed to the infamous London Smog in England in 1952.

In addition to the region's topographic conditions, seasonal and daily temperature patterns contribute to particulate matter (PM) events. The Imperial and Mexicali Valleys are known for long summers and short winters. Extended periods of dry weather cause the formation of dust from undeveloped lands. Atmospheric cooling in the winter months reduces vertical mixing and produces inversion conditions (Meuzelaar, et al. 2005).

The Imperial Valley has the second highest weighted annual mean concentration of PM_{10} (PM with an aerodynamic diameter of 10 microns or less) in the United States. In 2003, EPA reported the weighted annual mean concentration of PM_{10} in Imperial County as 75 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$). The National Air Ambient Quality Standard for annual mean PM_{10} concentration is 50 $\mu\text{g}/\text{m}^3$ (EPA 2003).

HEALTH

A SCERP study completed in 2004 showed a strong correlation between asthma, temperature, and PM_{10} in both the Mexicali and Imperial Valleys. The correlation was slightly lower in Imperial Valley. Similar results were achieved by correlating acute respiratory syndrome and pneumonia with temperature and PM_{10} . This same study noted that humidity and temperature were less important variables in analysis of respiratory illnesses in the Imperial and Mexicali Valleys. In 2000, the Imperial Valley had California's highest hospital discharge rate for asthma—approximately 20 cases per 10,000 in the population. CDC has established a target annual discharge rate of approximately 15 cases per 10,000 people. The majority of all other counties in California fall well below this target (California Department of Health Services 2003).

Daily PM_{10} events occurring during evening hours are observed in many suburban and rural communities (Meuzelaar, et al. 2005) where major sources of PM_{10} generally do not exist. It is hypothesized that the PM responsible for the events is transported from nearby metropolitan or industrial areas. Mechanisms of transport vary between locations. A second part of the 2004 SCERP study identified the effect of evening PM events on individuals. This study occurred outside Ciudad Juárez, which unlike Imperial-Mexicali Valley is prone to wind gusts. Despite these conditions, researchers were able to detect a significant relationship between the evening PM_{10} events and instantaneous physiological effects such as reduced lung function and increased heart rate.

Investigating the health risks of PM is complicated because the composition of PM and its associated health effects varies based on a number of local conditions. A pilot study completed by SCERP researchers in 2003 attempted to estimate exposure risks and health effects of PM in the Paso del Norte airshed. This study integrated a number of local factors, including the nature and origin of PM and wind patterns with spatial distribution of at-risk populations. A result of the study was a GIS-referenced database. This technology allows researchers to produce more advanced models to uncover trends and anomalies in regional transport, air chemistry, atmospheric deposition, and at-risk populations (Meuzelaar, et al. 2005).

There are a variety of PM sources in the Mexicali and Imperial Valleys. Often the source determines the diameter of the particle emitted. Particles with a diameter of 2.5 microns (μm) to 10 μm are largely produced by factory smoke, mineral dusts, agricultural practices, pesticide use, and dust from construction sites and unpaved streets. These larger particles mainly deposit into the upper respiratory tract, initially causing mild respiratory conditions that eventually lead to weakened immune systems and immune responses. Particles 2.5 μm and smaller ($\text{PM}_{2.5}$) can penetrate the lower respiratory tract and the deep lung. $\text{PM}_{2.5}$ is a concern because health outcomes associated with it include severe immediate conditions such as aggravation of asthma, cardiovascular disease, acute respiratory illness, and premature death. The smaller particles are produced by the combustion of fossil fuel and include aerosols (Collins, et al. 2001). In 1997, EPA added new standards to cover $\text{PM}_{2.5}$ —an annual mean of 15 $\mu\text{g}/\text{m}^3$ and for a 24-hour average of 65 $\mu\text{g}/\text{m}^3$.

Aside from the diameter of PM_{10} , composition is an important indicator of health outcomes. In 1997, EPA identified geologic material as the major component of PM_{10} in U.S.-Mexican border valleys. An earlier study by Alvaro, et al., in 1991 analyzed PM_{10} from Mexicali and further characterized the geologic material as a mixture of 75% potassium aluminum silicates and 20% silica. Rats exposed to this dust developed a specific lung fibrosis condition similar to asbestos exposure (Collins, et al. 2001). Fine silica dust is associated with silicosis or “black lung disease” (Anderson, et al. 2001). Although cases of such conditions have not been identified or quantified, these studies allude to the severity of potential health conditions for Mexicali residents.

Health conditions related to PM in the Imperial Valley have been characterized to a greater extent than in Mexicali. Imperial Valley has lower annual average concentrations of PM_{10} (75 $\mu\text{g}/\text{m}^3$) than Mexicali (240 $\mu\text{g}/\text{m}^3$). Imperial County had the highest asthma hospitalization rate in California from 1983 to 1994. During that same period of time, childhood asthma hospitalizations in Imperial County increased by 54%. In the city of Calexico, the prevalence of doctor-diagnosed asthma in 6- to 7-year-olds was 15.1% and in 13-year-olds was 26.5% (Impact Assessment Inc. 2001). Imperial County had the highest age-adjusted asthma hospital discharge rate

from 1998 to 2000—approximately 20 per 10,000 residents. This rate is two times greater than the state rate (10 per 10,000 residents) (California Department of Health Services 2003). Based on a positive association between PM_{10} and death rates in more than 20 U.S. cities studied for eight years by Samet, et al. (2000), it was estimated that reducing the daily mean PM_{10} concentration by $10 \mu\text{g}/\text{m}^3$ would yield a 3.0% reduction in asthma attacks (Sadalla 2005).

Given the nature and prevalence of health outcomes related to PM, it follows that a financial burden exists for families and communities where PM concentrations are elevated. The National Research Council (2002) analyzed the new $PM_{2.5}$ standards and estimated they would reduce the amount of money spent nationally treating PM-related illness by \$1.8 billion to \$75.1 billion annually by preventing 3,300 to 15,600 fatal cases. Additional savings for preventing lost workdays, restricted activities, hospital admissions, and treatment of chronic respiratory diseases amounted to more than \$1 billion (NRC 2002).

EL PASO-CIUDAD JUÁREZ

Traditionally, air quality has been associated with the ambient environment. In the past few decades, an increasing number of episodes of illness and mortality related to air quality within buildings and homes, including in Ciudad Juárez, Chihuahua, has brought indoor air quality to the attention of researchers and policymakers. A study performed by CDC from 2001 to 2003, for example, estimated that 480 U.S. residents died per year and 15,000 were treated in hospitals as a result of non-fire-related CO poisoning (CDC 2005) in an indoor environment.

Carbon monoxide poisoning is an acute reaction to the inhalation of CO. Symptoms vary according to dose. A low dose of CO produces headache, nausea, dizziness, and shortness of breath. Such symptoms can easily be ignored or attributed to other causes. Occupational studies have shown that exposure to low levels of CO over extended periods of time can result in long-term effects such as

heart disease and neurobehavioral effects (Raub, et al. 2000). Exposure to high concentrations (approximately 1,000 ppm or greater) of CO will cause death.

A number of studies performed in the United States have identified common risk factors for CO poisoning, and the leading risk factor for CO poisoning is cool, winter temperatures. During the CDC study, each December approximately 59 U.S. residents died from CO poisoning and 69 died in January. Over the course of the two-year study, 480 deaths were attributed to CO poisoning. A secondary risk factor identified for unintentional CO poisoning in California by Lui, et al., in 2000 is the use of a forced-air gas heater (Montoya 2003). Both these risk factors are important to the Ciudad Juárez region because extreme temperatures in the winter force families to run heaters throughout the night. Poor construction in the unplanned communities of Ciudad Juárez leaves these homes with inadequate ventilation to prevent concentration of CO (Corella-Barud 2001).

In Ciudad Juárez, elevated CO levels in the home affects approximately one-third of low-income households. For the past 12 years the number of CO poisoning cases in Ciudad Juárez was 1,381, or approximately 115 per year (Montoya 2003). Incidence of unintentional CO poisoning in Ciudad Juárez is approximately one-fifth of the incidence of CO poisoning in United States, while the population of Ciudad Juárez is 3/1,000 the population of the United States. If incidence in the United States is used as a comparative baseline, this indicates the incidence of CO poisoning disproportionately affects Ciudad Juárez.

It follows that the numerous cases of unintentional CO poisoning in Ciudad Juárez may indicate risk factors that differ greatly from those of the United States. One striking difference between the U.S. border cities and Ciudad Juárez is the gender of the at-risk population. In the United States, men are 2.3 times more likely to die from CO exposure (CDC 2005). The CDC study suggested men were more likely to operate generators or power tools in poorly ventilated areas such as a workshop or garage. A study performed by SCERP researchers in Ciudad Juárez identified women and children as the at-risk population for indoor CO poisoning because of their greater

likelihood to spend time in the home and the greater incidence of poor ventilation in those homes. Sources of CO in the household were un-vented cooking and heating units (Corella-Barud 2001).

AIR TOXICS

In 1990, the U.S. Clean Air Act was amended to add 189 new chemical compounds to the list of regulated air pollutants. This diverse group of chemicals is known as Hazardous Air Pollutants (HAPs), and they range from hydrocarbons such as benzene to heavy metals and fibers such as asbestos. All HAPs have negative health effects, including cancer, immune system suppression, neurological harm, and reproductive harm. Some developmental and respiratory health problems are associated with exposure to HAPs.

In light of the risk factors that exist in border communities, the potential for human exposure to HAPs is great. The rapid industrial development that has occurred at the border over the past two decades has brought increasing point sources, such as power plants and factories, and mobile sources, such as diesel engines. Rapid population growth, of course, means more people are exposed to HAPs. Unhealthy living conditions also contribute to the generation of HAPs. One condition, for example, is the open burning that occurs when waste disposal services are insufficient.

In some cases, health effects of HAPs are intensified by the presence of PM. PM, specifically PM₁₀, acts as a vehicle for transporting HAPs to the lung, where it can access the target organs via the bloodstream. PM₁₀ can assimilate chemical contaminants of diverse origins on their irregular surfaces or in their porous interior, according to Vogel, et al. (1995). One specific family of compounds, polycyclic aromatic hydrocarbons (PAHs), is known to exhibit this type of interaction. PAHs can exist in two forms, vapor phase (low molecular weight) and particle phase (high molecular weight). Although the phase of PAHs can be helpful in determining the source, either form has carcinogenic effects on human health (Bi, et al. 2003).

To characterize the extent of PAHs in PM, a SCERP study in 1995 sampled high-traffic and industrial areas in Nuevo Laredo, Tamaulipas. This study observed weekend peaks in PM₁₀ and higher

concentrations of particle phase PAHs in sampling sites near high-traffic areas. The study identified particle phase PAHs, which are more readily transported by PM_{10} and more likely to be inhaled by humans, thus causing irritation of the upper respiratory tract (Vogel, et al. 1995). The peaks in PAHs and PM_{10} were attributed to increased vehicle traffic during weekends. Overall concentrations of PAHs were lower in winter than summer, but the difference was not significant. PAH concentrations remained well below concentrations experienced in other urban communities such as London and Manchester, in Britain. Fortunately, the Nuevo Laredo region is prone to contaminant dispersion, largely due to winds originating from the Gulf of Mexico and adjacent plains. Carcinogenicity of PAHs was not addressed by this study, but identifying PAH distribution and concentration in PM_{10} yielded a framework for future investigations.

Future studies should be implemented in regions with high levels of commercial traffic, specifically areas where heavy trucks are left idling for extended periods of time, such as at border crossings. Exhaust from diesel engines is a primary source of PM_{10} and PAHs. Approximately 20,000 premature deaths per year in the United States are attributed to diesel exhaust (Barrett 2005). Studies identified by Lwebuga-Mukasa, et al. (2004) focused on the increased risk of asthma and respiratory illness associated with living near congested portions of the U.S.-Canadian border. In the cross-sectional study conducted by Lwebuga-Mukasa, et al. (2004), findings showed people living in proximity to the border ports of entry and main corridors have a greater risk for developing asthma and respiratory illness than residents of neighboring communities (Lwebuga-Mukasa, et al. 2004). An earlier study by Oyana and Lwebuga-Mukasa found that people living between 204 meters and 700 meters from pollution sources (such as a border crossing) comprised two-thirds of the asthmatic sufferers in the study region (Oyana and Lwebuga-Mukasa 2004).

Open burning of trash is another important source of PAHs in the U.S.-Mexican border region because this activity may regularly occur near homes, thus exposing the residential populations. Open burning is known to release significant amounts of PAHs, including compounds linked to endocrine disruption (Sidhu, et al. 2005). A

growing body of evidence is strengthening the association between PAH exposure and fetal harm. A study published in March 2005 by Cancer Epidemiology Biomarkers and Prevention shows fetuses exposed to PAHs in utero may be 10-fold more susceptible to DNA damage (which increases the risk of cancer) than the mother (Perera, et al. 2005).

Heavy metals are included in the list of HAPs. Within the category of heavy metals, none has gained more notoriety in the past decade than mercury. A SCERP study in the Caballo Reservoir, located in south-central New Mexico, showed mercury deposition was occurring, but not at levels that threatened humans or wildlife (Caldwell, et al. 2000). Dry deposition (the process of particles falling directly from the atmosphere to the earth's surface) was responsible for 13% to 85% of the total depositional input to the Caballo Reservoir. Wet deposition (the process whereby compounds are stripped from the air by rain or moisture) is not likely to be a major mechanism of transport for mercury at the U.S.-Mexican border because the region receives relatively small amounts of rainfall. In the United States, mercury deposition is greatest in the Northeast (National Atmospheric Deposition Program 2003). A combination of rainfall and sources of mercury, such as coal-fired power plants, are present in the region. Similar sources are found in the Mexican border region (for example, Carbon I and II near Piedras Negras, Coahuila). Modeling mercury emissions and deposition in this region may yield a better understanding of potential human exposures. Mercury causes developmental and neurological effects in adults, children, and fetuses when consumed in the methyl-mercury form, which is found in fish and shellfish. Other forms of mercury can result in damage to the gastrointestinal tract, nervous system, and kidneys (EPA 2005).

Another heavy metal, tungsten, has come under scrutiny only recently. Tungsten was nominated for inclusion in the National Toxicology Program (NTP) in 2004 because of its ability to form fibrous whiskers, similar to asbestos or silica (NTP 2004). The city of Sierra Vista, Arizona, is located within the U.S.-Mexican border region and there are a number of tungsten mines within close proximity. In addition, the region has suffered from lack of rainfall over the past decade, theoretically allowing for tungsten particles to

become airborne. Studies supported by the community have found elevated levels of tungsten in trees as well as in air samples. Twelve cases of leukemia have appeared among children in Sierra Vista since 1997, four times the expected number, given a population of 40,000, over the same period of time (McClain 2005). An investigation of typical environmental causes of leukemia was conducted by the Arizona Department of Health Services; it ruled out benzene, arsenic, and radiation as causes for the increased rate of cancer (Arizona Department of Health Services 2003). A number of abandoned mines and metal smelters exist throughout the U.S.-Mexican border region, and coupled with arid conditions, this makes for a grave potential for human exposure to HAPs.

CONCLUSION

On a regional level, the health effects of air pollution should be addressed by identifying the specific health impact that is most significant because of the combination of its intensity and the number of people affected. As well, implementing controls proven to reduce the output of pollutants scientifically linked to a particular health impact can also help address the health effects of air pollution. Although health outcomes range from simple eye and respiratory irritation to cancer, many of the controls for pollutants can target more than one pollutant and health outcome.

To date, asthma and respiratory ailments appear to be the leading health effect of air pollution in the region. Both ozone and PM have been scientifically identified as causes or triggers of asthma. Control of ozone and control of PM emissions can be conducted in parallel, as they share the common source of vehicle emissions. Controlling vehicle emissions will reduce ozone and PM levels, as has been seen in Los Angeles and San Diego. Such a control strategy would target not only ozone precursors but also pollutants such as PAHs, which can also be problematic when intensified in the presence of PM. This strategy has a trickle-down effect to less prevalent health outcomes, including cancer. One such specific control, which would require cooperation at the regional level, is the construction of a transborder freight rail expressway, similar to the Alameda Corridor in Los Angeles. The construction of the Alameda Corridor, a 20-

mile rail line that links the Ports of Long Beach and Los Angeles to a transcontinental freight network hub near downtown Los Angeles, is predicted to reduce traffic congestion on surface streets, reduce emissions from idling cars and trucks by 54%, and increase efficiency of the cargo distribution network to accommodate growing international trade in the two busy ports, according to the Alameda Corridor Transportation Authority.

On a local level, efforts to increase personal responsibility for health should be undertaken in communities. Without individuals understanding and respecting air pollution controls, the controls will not be effective because the will to comply will be diminished. In the border region, where enforcement is lacking, personal responsibility for health is a plausible alternative. Targeting air quality problems, such as open burning of trash and indoor air quality, by increasing awareness and offering alternatives to traditional methods can improve current conditions.

Local interventions should have a health education component so local community health service workers are able to identify symptoms of air pollution-related diseases accurately. This effort should be made in conjunction with increasing access to community health services. The overall effects would be a decrease in the underestimation of health outcomes attributed to air pollution.

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VI

Promoting Air Quality Improvements with Carbon Finance

David Noble

ABSTRACT

This paper examines the potential to promote air quality improvements in northern Mexico with carbon finance and identifies elements of an institutional framework for facilitating project development. The focus is on energy efficiency (EE) activities under the Clean Development Mechanism (CDM) of the Kyoto Protocol, because clear potential exists in this area. However, the general discussion can be extended to many other project types, including landfill gas-to-energy and other renewable energy projects, agricultural projects, fuel substitution and clean vehicle/fleet projects, and non-CDM carbon markets.

There is a huge opportunity for air quality improvements through EE measures in northern Mexico. Unfortunately, numerous barriers to EE projects exist, and many efficiency gains and air quality improvements go unrealized. Participation in CDM could be a catalyst to more successful EE project development. Energy savings generate carbon credits that could be sold under CDM. The revenues could be used to redress certain financial barriers to EE implemen-

tation. High-quality credit opportunities might also induce technical assistance (as they already have) and technology transfer from industrialized countries.

High transaction costs and a low carbon revenue stream are barriers to developing EE projects under CDM. The notional solution is to advance a portfolio of projects and bundle the credits through an intermediary. Transaction costs are thus spread over a number of projects and, collectively, the projects generate enough credits to meet the market's demands. In practice, this approach has proven difficult.

However, Mexico, and northern Mexico in particular, has a comparative advantage in the greenhouse gas (GHG) marketplace vis-à-vis many other developing countries:

- It is a large country with a carbon-intensive economy and growing energy demand
- Energy-saving opportunities are relatively homogeneous and highly replicable
- It is the only developing country in the world with free trade agreements with Canada, the United States, the European Union, and Japan, and it has several bilateral agreements with Annex-I countries, including Canada and Japan, to promote CDM
- Mexico's business culture is more familiar to many of the multinational businesses that will be prominent buyers of carbon credits, and this may translate into preference for Mexican-sourced credits vis-à-vis credits from other potential suppliers

Many organizations and institutions are currently engaged in EE-related activities in northern Mexico. Their interests are clearly convergent and there is an opportunity to align their various activities to work collaboratively toward their common goal. The various organizations should explore the potential to collaborate more closely. This begins as an exploratory process and, if successful, converges to a commitment to a framework for collaborative action. The aim is to identify synergies, align activities, and mobilize the resources required to initiate and sustain a program for CDM EE activities.

With the first Kyoto commitment period beginning in less than three years and the uncertain value of post-2012 credits, it is critical to act quickly. With U.S. and international cooperation, it is possible to develop Mexico's advantage and capitalize on the opportunity to use carbon finance to promote energy efficiency and other air quality improvement opportunities.

Fomento de Mejoras a la Calidad del Aire con Financiamiento de Carbono

David Noble

RESUMEN

Este capítulo examina el potencial para fomentar una mejor calidad del aire en el norte de México con el financiamiento de carbono e identifica los elementos de un marco institucional para facilitar el desarrollo de proyectos. El enfoque es en las actividades de eficiencia energética (EE por sus siglas en inglés) amparadas en el Mecanismo de Desarrollo Limpio (MDL) del Protocolo Kyoto ya que existe un claro potencial en esta área. Sin embargo, la discusión general puede extenderse a muchos otros tipos de proyectos incluyendo la conversión del gas de los rellenos sanitarios a energía y otros proyectos de energía renovable, proyectos relativos a la agricultura, proyectos de sustitución de combustible y de vehículos/flotas limpias y mercados de carbono sin un CDM.

Existe una gran oportunidad para mejorar la calidad del aire a través de medidas de eficiencia energética en el norte de México. Desafortunadamente, existen numerosos obstáculos para proyectos de EE, y no se logran realizar muchas ganancias de eficiencia y mejoras a la calidad del aire.

La participación en el CDM pudiera ser un catalizador para un desarrollo de proyectos de EE más exitosos. Los ahorros de energía generan créditos de carbono que podrían venderse bajo el MDL. Las ganancias pudieran ser utilizadas para remediar ciertos obstáculos financieros para la implementación de la EE. Oportunidades de crédito de alta calidad pudieran también inducir asistencia técnica (como ya lo han hecho) y transferencia de tecnología proveniente de países industrializados.

Los altos costos de las transacciones y un flujo bajo de ingresos de carbono son barreras para el desarrollo de proyectos de EE bajo el MDL. La solución hipotética es adelantar una cartera de proyectos y agrupar los créditos a través de un intermediario. Los costos de las transacciones son por lo tanto extendidos en diversos proyectos y colectivamente, los proyectos generan suficientes créditos para satisfacer las demandas del mercado. En la práctica, este enfoque ha resultado difícil.

No obstante, México, y en particular en el norte de México, tiene una ventaja comparativa en el mercado de los gases de efecto invernadero (GHG, por sus siglas en inglés), con relación a muchos otros países en vías de desarrollo.

- México es un país grande con una economía intensiva de carbono y creciente demanda de energía.
- Las oportunidades de ahorro energético son relativamente homogéneas y altamente reproducibles.
- Es el único país en el mundo en vías de desarrollo con tratados de libre comercio con Canadá, los Estados Unidos, la Unión Europea y Japón, y tiene varios acuerdos bilaterales con países Anexo-I, incluyendo Canadá y Japón, para fomentar el MDL.
- La cultura empresarial de México es más familiar para muchos de las empresas multinacionales que serán los compradores prominentes de créditos de carbono. Esto podría traducirse como una preferencia créditos de fuentes mexicanas en relación con créditos de otros posibles proveedores.

Numerosas organizaciones e instituciones actualmente participan en actividades relacionadas con la EE en la parte del norte de México. Existe claramente una convergencia de sus intereses y existe una

oportunidad para alinear sus diversas actividades para trabajar en colaboración hacia su fin común. Las diferentes organizaciones deberían explorar el potencial de colaborar más estrechamente. Esto comienza como un proceso de exploración y, si resultara exitoso, converge en un compromiso de un marco para acciones en colaboración. El objetivo es identificar sinergias, alinear las actividades y movilizar los recursos requeridos para iniciar y sustentar un programa para las actividades de EE del MDL.

Con el primer periodo de compromiso de Kyoto que inicia en menos de tres años y con el valor incierto de créditos post-2012, es crítico actuar rápidamente. Con la cooperación estadounidense e internacional, es posible desarrollar la ventaja de México y capitalizar sobre la oportunidad de utilizar el financiamiento del carbono para fomentar la eficiencia energética y otras oportunidades para mejorar la calidad del aire.

INTRODUCTION

This paper introduces the potential role of carbon finance in facilitating local initiatives to improve air quality in northern Mexico. It reviews some of the carbon finance opportunities in Mexico and examines the specific opportunities and challenges associated with providing carbon financing for energy efficiency (EE) project activities in particular. Numerous organizations are currently involved in carbon finance and/or EE activities in northern Mexico and their interests are clearly convergent. Collectively, and in synergy, they can address many of the challenges to EE, and, it is hoped, catalyze wide-scale project implementation. The challenge is to craft and mobilize an appropriate framework for institutional collaboration.

THE INTERNATIONAL CARBON MARKETS AND CARBON FINANCE

Greenhouse gas (GHG) emission trading has existed for more than 10 years, but has grown substantially in recent years with the entry into force of the Kyoto Protocol and the emergence of numerous voluntary and mandatory trading schemes. For developing coun-

tries, the protocol's Clean Development Mechanism (CDM) is perhaps the most significant international market. CDM is a project-based mechanism intended to provide a cost-effective approach for industrialized (Annex-I) countries to meet their emission reduction commitments under Kyoto, while simultaneously contributing to the sustainable development of developing countries and engaging them in the global climate regime. Under CDM, Annex-I countries (or private entities within those countries) can invest in GHG abatement projects in developing (host) countries so long as those projects result in real and measurable GHG emission reductions and contribute to the host country's sustainable development.

CDM project activities generate certified emission reductions (CERs) equivalent to the GHG emissions offset by the project activities. CERs are fully fungible and tradable carbon credits that can be sold on the international carbon markets. From the perspective of a (host country) project sponsor, leveraging CERs represents an additional revenue stream that enhances a project's overall economics.

For example, Sistemas de Energía Internacional SA (SEISA) recently developed a project to support three landfill gas facilities in Mexico. Decomposition of organic materials in landfills generates methane, which is a much stronger GHG than carbon dioxide (CO₂). Methane from two facilities will be captured and used for power generation with a nominal capacity of 9 megawatts (MW), while methane from the third facility will be flared. Both the power generation and the flaring essentially convert the methane to CO₂ and thus reduce the GHG effect. The World Bank purchased the net reduction of 2 million tons of CO₂ equivalent (tCO₂e) anticipated from the project up to 2012 for \$8.4 million.

The carbon market has grown steadily in recent years. With the Kyoto Protocol recently going into effect, the market is almost certain to expand rapidly in the next few years. The CDM market potential is estimated at 1,250 million tons of CO₂ equivalent (Mt CO₂e) by 2012. As the CDM market grows and matures, CER prices are expected to rise. Haites estimated an average price of \$11/tCO₂e (Haites 2004).

NORTHERN MEXICO: AN ATTRACTIVE SUPPLIER OF CERS

Mexico is widely recognized as an attractive potential supplier of CERS. Mexico has a large and carbon-intensive economy, with ample GHG emission reduction opportunities. Northern Mexico, in particular, offers a tremendous potential supply for several reasons:

1. Power generation is especially carbon-intensive. Five of the six border states rely predominantly on fuel oil or natural gas (50% combined) and coal (41%).
2. Energy demand is growing rapidly. Electricity demand growth is projected at roughly 6% annually over the coming decade. At this rate, electricity consumption will double in 12 years. From an environmental and GHG standpoint, meeting this demand should include both a proportional shift toward using renewable energy sources and a greater emphasis on energy conservation or efficiency.
3. Strong institutional capacity exists. Mexico has strong bi- and trilateral cooperation with the United States and Canada on energy and environmental issues, particularly in the northern region.
4. Several organizations and institutions are actively involved in the development, deployment, and promotion of a wide range of innovative environmental technologies and processes in the border region.
5. Mexico is the only developing country in the world with free trade agreements with Canada, the United States, the European Union, and Japan. Because of these agreements, Mexico can readily access GHG-friendly technologies.
6. The hot, dry climate in northwestern and north-central Mexico tends to favor EE investments. The economic returns on these investments are greatest in regions where seasonal variation in energy and capacity charges is greatest.

Business culture is also an advantage for Mexico. Mexico's business culture and language are more familiar to many of the multinational businesses that will figure prominently as buyers in the carbon markets. This may translate into a greater willingness to pur-

chase Mexican-sourced credits than credits from other major suppliers, such as India or China, where cultural differences are more pronounced.

To date, Mexico has been slow to engage in CDM. The country established its Designated National Authority (the national body, required under CDM, that evaluates projects against the country's sustainable development criteria and approves appropriate projects) in 2004 and is only now developing the capacity to participate effectively. In the north, a strategic focus on GHG emission reductions is lacking. This is partly due to Mexico's close cooperation with U.S. institutions on border environmental management. Because the United States is not engaged in the Kyoto mechanisms, U.S. institutions active in the region are unable or reluctant to focus on GHG emission reductions.

However, Mexico has received heavyweight institutional support from Annex-I countries. The Japan Bank for International Cooperation (JBIC) and the Canadian government have signed bilateral agreements with Mexico to promote CDM opportunities in Mexico, and Canada funded the World Bank to deliver its technical assistance and capacity-building program, CF Assist, in Mexico in 2005.

The Kyoto Protocol sets emission reduction targets for the period between 2008 and 2012. As this commitment period draws near, Mexico appears keen to participate in and benefit from CDM and other carbon markets.

CARBON FINANCE OPPORTUNITIES FOR MEXICO

In 2001, the trilateral Commission for Environmental Cooperation (CEC) produced a report on potential investment opportunities arising from carbon offset projects in the electric power generation, steel production, and land-use change and forestry sectors in Mexico (CEC 2001). The report suggested potential markets of \$31 million in electric power generation from 1999 through 2009 and \$23 million to \$51 million in the land use change and forestry sector from 1999 through 2030 (based on a price estimate of \$10/tCO₂e). A sur-

vey of 13 large- and medium-sized steel producers suggested carbon emission reductions from various EE projects in the steel sector had a market value of \$1.2 million.

A Canadian government office mandated to facilitate Canadian participation in CDM and Joint Implementation projects, the CDM-JI Office, has studied CDM opportunities in Mexico and ranked those opportunities related to energy (on both the supply and demand sides) and carbon sequestration across various sectors (Table 1).

There is a significant opportunity to support landfill gas-to-energy (LFGTE) projects in Mexico with carbon finance. These important projects simultaneously reduce methane emissions and various environmental impacts associated with municipal solid waste disposal (such as methane migration, odors, and local air and water pollution), and provide a source of renewable energy. At least two LFGTE projects have already been developed in northern Mexico, including the aforementioned SEISA project and a project in Monterrey, Nuevo León, that was developed with support from the Global Environment Facility in the 1990s. The Monterrey project has an installed capacity of 7 MW and is expected to result in GHG emission reductions of 3.6 MtCO₂e over its lifetime. Six more landfill sites are currently being screened for LFGTE development in Mexico under the World Bank's LFGTE Initiative in Latin America.

Mexico and the United States are also founding partners of the newly established Methane to Markets Partnership. The partnership is intended to serve as a framework for international cooperation to advance the recovery and use of methane as a valuable clean energy source to increase energy security, enhance economic growth, improve air quality and industrial safety, and reduce GHG emissions. It initially targets three major methane sources: landfills, underground coal mines, and natural gas and oil systems. Partners will collaborate to develop strategies and markets for methane recovery and use through technology development, demonstration, deployment and diffusion; implementation of policy frameworks; identification of ways and means to support investment; and removal of barriers to collaborative project development and implementation (Methane to Markets Partnership 2006).

Table 1. Overview of Opportunities to Apply the Clean Development Mechanism in Mexico

CDM-JI Projects ¹	Energy Generation	Oil and Gas Industry	Forestry	Commercial Sector	Agriculture	Industrial Processes
Alternative and renewable energy	***	***	*	*	*	***
Co-generation, power plants	***	**				*
Industrial ecology/eco-efficiency	***	***		***		***
Efficient use of electrical energy	*					
Carbon sequestering and capture			***		***	
Waste management		**		***	**	***
Capacity building and infrastructure	***	**	***	**	*	**
Sustainable agriculture					***	
Sustainable buildings				***		***

¹ CDM-JI = Clean Development Mechanism-Joint Implementation

* Fair opportunity

** Good opportunity

*** Excellent opportunity

Source: Clean Development Mechanism-Joint Implementation Office, Government of Canada

CARBON FINANCING FOR ENERGY EFFICIENCY IN NORTHERN MEXICO

Energy conservation is critical to sustainable development in northern Mexico. Energy demand in the Mexican border region is growing rapidly and there are concerns about the continued availability and future cost of electricity in the border region. Energy conservation, distributed generation, and renewable energy must become an integral component of future energy policies and must play a key role in meeting the region's energy needs (Western Governors' Association 2004). Moreover, energy generation from conventional sources is a major source of air emissions that impacts air quality and human health (Table 2)

Significant opportunity for air quality improvements through energy efficiency measures exists in northern Mexico. In 2004, the Western Governors' Association (WGA) investigated the potential energy savings from energy efficiency measures in key customer sub-sectors (manufacturing; hospitality, commerce, and trade; and hospitals, government, and education) in Matamoros, Tamaulipas; Ciudad Juárez, Chihuahua; and Tijuana, Baja California (Western Governors' Association 2004). It estimated a market potential for cost-effective energy savings of approximately 818.8 gigawatt hours per year (GWh/year), mostly from small projects (less than 500,000 kilowatts per year [kWh/year]).

Using the emission rates in Table 2 as proxies for emission rates from northern Mexico power plants and an 18% average transmission and distribution loss, these energy savings, if fully realized, would generate emission reductions crudely estimated at 10,966 tons of sulfur dioxide (SO_2), 1,768 tons of nitrogen oxides (NO_x), and 33 kilograms of mercury (Table 3). Note that the EE measures are end-use electric efficiency measures. Total electric energy savings are approximately 18% higher because they include foregone transmission and distribution losses. Emission reductions are generated at-source, so total emission reductions are calculated from total energy savings. The emission reductions are measured against what would have been emitted in the absence of the EE measures, all else being equal.

Table 2. Summary of Annual Emissions from Selected Mexican Power Plants

Pollutant	Number of Facilities Included	Average Emission rate Across Facilities	Total Emissions from Included Facilities
SO ₂	82	11.35 kg/MWh	1.6 million tons
NO _x	82	1.83 kg/MWh	0.25 million tons
Hg	3	0.034 kg/GWh	1,025 kilograms
CO ₂	82	688 kg/MWh	94 million tons

Source: Commission for Environmental Cooperation

Table 3. Potential Energy and Emission Reductions from End-Use Energy Efficiency Measures

Category of Saving	Amount of Saving
Potential end-use energy savings	818.8 GWh/year
Additional savings on the grid due to foregone transmission and distribution losses (18%)	179.7 GWh/year
Total potential energy savings	998.5 GWh/year
Emission reductions from energy savings, if fully realized, assuming emission rates identified in Table 2	
SO ₂	10,996 tons/year
NO _x	1,768 tons/year
Hg	33 kilograms/year
CO ₂	664,735 tons/year

Source: Western Governors' Association

If fully realized, the same energy savings would generate annual CO₂ emission reductions of approximately 664,735 tons. If 100% of these reductions generate marketable credits, then at \$5/tCO₂e to \$11/tCO₂e, the CERs would carry an undiscounted market value of between \$16.6 million and \$36.6 million over the five-year period from 2008 through 2012. The actual quantity and value of CERs could differ significantly from the estimates presented here because

both quantity and price depend on many factors. The estimates here are based on a crude analysis and are intended for illustrative purposes only.

Unfortunately, numerous barriers impede EE project development and many opportunities go unrealized. Table 4 shows the barriers identified by WGA and the recommended actions suggested by the organization to overcome them and encourage project development.

Revenues from the sale of CERs could be used to redress certain financial barriers to EE implementation, for example, by financing an EE program and/or enhancing project economics sufficiently to attract customers and energy service companies (ESCOs). High-quality credit opportunities might also induce technical assistance (as it already has) and technology transfer from industrialized countries.

Thus, while the commonly stated purposes of increasing EE in the region are improved air quality and, in certain cases, increased energy security, it is worth recognizing that the same measures can generate GHG emission reductions that can be sold. This is true for many other air quality improvement strategies, including the recommendations being considered through an ongoing binational process initiated at the 2004 Air Policy Forum by the U.S. Environmental Protection Agency (EPA) and Mexico's Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) (EPA 2005). Table 5 indicates that in many cases, GHG emission reductions and local air quality improvement are complementary. Carbon finance should be viewed as a facilitating mechanism rather than a competing strategy.

BARRIERS TO CARBON FINANCING FOR ENERGY EFFICIENCY

However, while the total potential energy savings and emission reductions from EE measures are considerable, the potential credits from individual projects (such as EE measures implemented at a specific facility) are generally quite small. In many cases, projects generate from a few hundred to a few thousand tons of CO₂ emission reductions (Table 6). By contrast, it is generally accepted that the

Table 4. Barriers and Recommendations to Encourage EE in Northern Mexico

Barriers	Recommendations
Lack of program funding for implementing agencies	Assist local agencies and customers in obtaining alternative financing
Lack of financing options for interested customers	Create a revolving loan fund for small projects
Lack of awareness and technical knowledge among potential customers	Initiate educational activities in collaboration with local groups
Insufficient technical assistance for project identification and evaluation	Provide third-party technical expertise to interested customers
An undeveloped energy services industry	Develop business models to deliver energy-efficiency services to the private sector and support the development of energy service industry associations
Insufficient market data to target services to appropriate sectors	Collaborate with national and local agencies to develop energy consumption data at the local level that is classified by sector and sub-sector
Difficulty in establishing project proponents within customer organizations	Develop a coaching system to assist facility managers and aid in completing projects successfully
A regulatory environment that hampers private energy projects	Participate in the utility reform process to support private energy projects

Source: Western Governors' Association

Table 5. Potential Elements of an Air Quality Improvement Strategy

Elements of a Strategy to Limit Local Air Pollution	Elements that would Simultaneously Limit Local Air Pollution and Greenhouse Gases
Pave dirt roads Coordinate U.S.-Mexican fuel standards Develop air/water TEIAs¹ Develop comparative health risk assessment Set up mobile air pollution lab program Unify common airbasin monitoring and analysis Create binational emissions inventory Develop binational air quality indicators Establish indoor ambient air quality standards Supply safe alternatives Coordinate binational air basin trades Create clean air investment fund Engage private sector with ISEPs² Facilitate public education Suppress dust/erosion Mitigate agricultural burning Farm deserted areas Monitor open burning activities	Improve vehicular inspection and maintenance Retrofit or remove super-emitters Diversify transit/transport systems Electrify truck stops Plant green windbreaks Mitigate CAFOs³ Retrofit or remove super-emitters Promote alternative fuels Create/promote alternative/mass transit Provide alternative fuels Substitute fuels Expand natural gas distribution Provide alternative fuels Minimize trash burning Regulate and modify tire burning operations

¹ TEIAs are transboundary environmental impact assessments

² ISEPs are international supplemental environmental projects, implemented in lieu of fines

³ CAFOs are confined animal feeding operations

Source: Author

smallest viable projects will generate more than 100,000 tons over their lifetime, and World Bank statistics show that the average size of a Latin American project is currently approximately 1 million tons (Business News Americas 2005). (Here, “viable” refers only to the carbon finance element of a project, not the project itself. Projects must generate minimum quantities of credits to attract investors and overcome transaction costs, as described below).

Developing carbon credits is not a cost-free activity. Transaction costs are incurred while completing the project cycle from evaluation to certification of the credits. These costs are over and above costs associated with assessing technical feasibility, project design, or implementation. Most are relatively fixed, one-time costs. Monitoring and verification costs are the exception—these elements can vary according to project size and will recur on a defined schedule.

**Table 6. Potential CERs from End-use EE Measures
in Selected Mexican Facilities**

Facility	Energy Efficiency Measures	Annual Energy Savings (kWh)	Potential Credits (2008–2012)	Value (at \$10/ton)
Aduana Colombia	Lighting	382,798	1,554	\$5,540
Mexsecurit	Lighting	65,354	265	\$2,650
Plasticos Rex	Lighting	271,034	1,100	\$11,000
Nutrimex	Lighting; motors	112,344	456	\$4,560
Asesores Aduanales	HVAC	129,500	526	\$5,260
Dicex	HVAC	203,500	826	\$8,260
Int’l Trade Facility Center	Lighting	131,175	532	\$5,320
Aqua Lung de Mexico	Lighting; HVAC	415,633	1,687	\$16,870
Total		1,711,338	6,946	\$69,460

Source: Information in the first three columns came from Border Energy Case Studies; data in the last two columns were calculated by the author

Promoting Air Quality Improvements with Carbon Finance

Table 7 describes estimated transaction costs for energy efficiency projects in an established Canadian domestic GHG trading system. The estimates are based on a “typical” EE project that would generate 10,000 tons per year.

Table 7. Transaction Costs for Developing Carbon Credits from EE Projects

Transaction Cost	Description	Cost Estimate, Low – High
Project Evaluation	Assess likely net offsets and revenues associated with the project	\$811 – \$4,054
Project Initiation	Establish ownership and/or negotiate ownership contracts	\$4,054 – \$20,267
Project Proposal	Develop project proposal, including establishing eligibility, baselines, boundaries and leakage, quantifying GHG reductions, developing a monitoring and risk management plan	\$2,027 – \$8,107
Validation	Review proposal to confirm eligibility, and confirm accuracy, completeness, and credibility	\$811 – \$4,054
Monitoring and Quantification	Measure GHG emission reductions and quantify the resulting credits	\$811 – \$4,054 in 1st year
		\$811 – \$1,621 in subsequent years
Verification	Third party review to confirm accuracy and quality of the evidence supporting the claim for credits	\$1,621 – \$4,054 in 1st year
		\$811 – \$2,837 in subsequent years
Total		\$16,631 – \$62,468

Source: Marbek Resource Consultants

De Gouvello and Coto (2003) provided similar estimates of transaction costs for small-scale CDM projects with estimates ranging from \$8,168 to \$78,300. They point out that the largest component of the transaction costs relates to fees for validation and verification and suggest that the cost can be reduced either by limiting the recurrent tasks of the Operational Entity (OE) (for example, by opting for multi-annual rather than annual verification), or by promoting the accreditation of low-cost OEs, typically by accrediting local firms that charge “local” rates, which are much lower than “international” consulting rates (De Gouvello and Coto 2003). Thus, in addition to the various traditional barriers that hinder EE project development, two further barriers hinder EE project development under CDM: high transaction costs (relative to total project development costs) and a low CER revenue stream (relative to the purchasing preferences of CER buyers).

The notional solution is to advance a portfolio of projects and bundle the CERs through an intermediary, then streamline the project development scheme as much as possible to minimize transaction costs. Thus, for example, a facilitating entity might be established to target sector-specific, small-scale activities. Ideally, the facility would act as a fund, combining seed capital to support project development with a portfolio of CERs for sale to investors, while simultaneously providing technical assistance to project developers to assist with project structuring, financing, capital-raising, and risk mitigation services throughout the project cycle. This is the general model of the World Bank’s Prototype Carbon Fund and Community Development Carbon Fund.

TOWARD AN INSTITUTIONAL ARCHITECTURE FOR FACILITATING ENERGY EFFICIENCY

Numerous organizations are currently involved in EE activities in northern Mexico and their interests are clearly convergent:

- WGA has formed a border energy task force, which operates the website borderenergy.org, to facilitate the flow of energy efficiency information regionally and is currently working to demonstrate successful energy efficiency programs in industrial facilities in the California-Baja California and El Paso-

Ciudad Juárez areas. WGA has agreed to finance audits for candidate facilities that commit to a serious effort to implement pilot project opportunities.

- The Border Energy Forum (BEF) brings together government, industry, and non-profit organizations from all 10 U.S. and Mexican border states on an annual basis to encourage information-sharing about energy efficiency, foster energy-related alliances between public and private sector groups throughout the region, and promote viable, innovative projects and policies.
- The Alliance to Save Energy (ASE) planned to implement in fiscal year 2005, with funding from U.S. Agency for International Development, the Watergy program in Tijuana and Monclova-Frontera. The program, aimed at improving EE in municipal water utilities, facilitates EE implementation by delivering training and energy audits and developing case studies to promote replication.
- Econergy International Corporation (EIC) is an energy services company that provides technical and investment advisory services and also manages a private equity investment fund dedicated to clean energy projects in Latin America, with a focus on Mexico.
- The World Bank delivered technical assistance and capacity-building in Mexico in 2005 through its CF Assist program. The program is intended to help build Mexico's capacity to participate effectively in the carbon markets and demonstrate how carbon finance can facilitate project development.
- Mexico's SEMARNAT is implementing, with support from the World Resources Institute (WRI) and the World Business Council for Sustainable Development, the GHG Pilot Program. From 2005 to 2007, the focus is on recruiting participants, developing partnerships, and capacity-building aimed at facilitating project identification and participation in future GHG emission-reduction initiatives.
- The Border Environment Cooperation Commission (BECC) and North American Development Bank (NADB) are sister institutions that work together to finance environmental infrastructure, including EE, in the U.S.-Mexican border region. BECC certifies the environmental integrity of projects

that are then considered for finance by NADB. NADB recently developed a bundling mechanism for EE projects and is arranging its first bundled project financing with several U.S. and Mexican ESCOs.

- The Comisión Nacional para el Ahorro de Energía (CONAE) is the Mexican government agency that specializes in energy efficiency, renewable energy, alternative fuels, and distributed generation. Its mission is to design and promote EE guidelines, foster renewable energy use, and promulgate EE standards.
- Mexico's FIDE (a non-profit, private trust) supports EE activities through audits, demonstration projects, and training.
- The Center for Resource Solutions (CRS) is developing an accounting system for renewable energy certificate trading in North America. The system could be adapted to support verification and certification for EE projects.

It is worth noting the interests of Annex-I countries. In the past, Annex-I countries have contributed resources aimed at developing high-quality CER prospects. For example, Canada partially funded a Project Design Document (PDD) Development Facility for India to stimulate CDM project activities. Similar contributions to promote opportunities in Mexico are certainly possible as the 2008–2012 Kyoto commitment draws near.

With the exception of the World Bank, EIC, and WRI, the organizations working in the region have focused almost exclusively on the energy efficiency and air quality aspects in their activities. There have been some collaborative efforts to promote EE in the region, but these have generally failed to produce significant impacts beyond the immediate project results, due in large part to the barriers identified in Table 4.

CDM could be the catalyst for more collaborative and successful EE project development in the region. For example, CER revenues could help finance an EE program or efforts to address other barriers to EE project development, and it could enhance project economics sufficiently to attract customers and ESCOs. High-quality

CER opportunities could also induce technical assistance (as it already has) and technology transfer in support of project development.

To work, a collaborative effort to develop EE projects will require at least two minimum conditions:

1. Multiple participants, with all of the required resources and expertise, and convergent and well-represented interests.
2. A framework for collaborative action that ensures an efficient scheme for developing projects and CERs. These conditions may seem intuitively obvious, but they should not be taken for granted. Multi-organizational initiatives are rarely easy. They require careful design and plenty of attention.

The challenge is to craft and mobilize an appropriate framework for institutional collaboration. With the first Kyoto commitment period beginning in less than two years and the uncertain value of post-2012 CERs, it is critical to act quickly. With U.S. participation, it is possible to do so and develop northern Mexico's advantage. Any initiative should thus be advanced under the rubric of energy efficiency and air quality to make U.S. participation more palatable. However, there needs to be a strategic focus on developing and capitalizing on the carbon asset.

Negotiating a framework for collaborative action begins as an exploratory process, and if successful, converges to a commitment by participants. The aim is to identify synergies, align activities, and mobilize the resources required to initiate and sustain a program for developing EE activities under CDM. Participants might consider a facilitating entity that bundles and assists a package of prospects, as described above. The facility could be delivered via a public-private clearinghouse model, with seed capital and technical assistance from the public sector and equity, bundling, and fee-for-service work provided by the private sector. Several examples can be imagined:

- The World Bank, WGA, and NADB (and EIC, if required) contribute seed capital; an Annex-I country government might also be invited to participate, depending on the facility's final design

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- The Border Energy Forum and the Alliance to Save Energy continue to identify pilot projects and support ongoing project identification and PDD development
- SEMARNAT aligns GHG Pilot Program activities with the facility
- The World Bank aligns CF Assist activities with key opportunities and ongoing initiatives in the region, develops baseline methodologies, and delivers capacity-building and technical assistance
- CONAE and FIDE engage Mexican industry associations and workgroups, professional associations, and participants of existing programs, and support activities of the facilitating agency with technical assistance, outreach, and government relations
- EIC provides energy services (such as audit, design, and implementation), GHG measurement, equity investment, bundling, and brokerage services
- CRS coordinates (with EIC and the World Bank) development and implementation of monitoring and verification infrastructure, and assists end-users with monitoring

The role of a private sector participant in the mold of EIC is critical. EIC is both an equity investor and an ESCO with technical and management expertise. It is experienced in carbon finance and brokerage services, and it has a Mexican office and operations. It could serve as equity investor and bundling organization, and could work with NADB and other organizations (such as commercial banks and leasing companies) to structure EE financial packages. With the prospect of involvement across all these areas and a large number of projects, an organization like this has a strong business case for committing and contributing to a major initiative.

Participants should target highly replicable project types (such as lighting efficiency) in targeted sub-sectors (such as manufacturing) and regions (such as north-central Mexico). The facilitating entity could easily adapt and disseminate a decision-support tool, such as the RETScreen International Clean Energy Project Analysis Software, to support low-cost project screening. Participants should seek pre-approval from the Mexican Designated National Authority

for all projects funded through the facility. These measures will help minimize the costs of administering the facility and project transaction costs. The aim here is to create an efficient project development scheme that maximizes the flow-through of projects.

Elements of this approach were shown to be successful by the San Francisco-based Proven Alternatives Capital Corporation (PACC). PACC established a fund to finance investments in commercial, industrial, and institutional EE programs and projects. It established specific technical criteria to create a relatively automatic and smooth approval process. Programs that meet the pre-approved criteria are not required to go through a detailed approval process, thus ensuring a rapid turnaround time and low transaction costs. The net effect is to expedite the approval of projects and expand the market for investment opportunities, thus allowing PACC to allocate fund expenses over a larger number of projects, lowering the fixed cost per dollar invested.

It will be critical to establish a set of default rules and standardized methods for bundling and declaring ownership of CERs generated through the facilitating entity. The costs of establishing ownership, in the absence of default rules, are expected to be highest for projects where there are a number of possible ownership claims, such as in the case of EE projects. Where default rules and standard contracts are in place, the costs of project initiation will decrease.

CONCLUSION

Carbon finance is not a panacea for potential energy efficiency projects (or any other type of air quality improvement projects). It is, however, a means for capturing the value of the GHG benefit and enhancing the economics of environmental investments, which simultaneously reduce GHG and other air pollutant emissions. In the U.S.-Mexican border region, this includes most priority air quality improvement measures, such as those aimed at enhancing clean and efficient energy and reducing vehicle emissions.

Absent any policy initiative to facilitate carbon finance, individual project proponents will use carbon finance to promote individual projects on a limited basis, principally because transaction costs

and market preferences favor large projects. The potential benefit of carbon finance will not then reach the majority of project opportunities that are smaller, and the overall benefit that accrues to the region will be less than otherwise attainable.

Carbon finance can have a much greater impact if delivered via a collaborative approach with broad institutional support, such as following the model of a facilitating entity. In this case, the carbon finance may be directed toward individual projects to support project implementation, or toward operating the facilitating entity itself. In either case, a collaborative and focused initiative to mobilize the carbon asset will enhance financing opportunities and result in more projects being implemented. Ultimately, an increase in project activities will improve air quality across the region.

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VII

Efforts of the North American Development Bank to Address Air Quality

Arturo Núñez Serrano

ABSTRACT

When originally established in 1995, the North American Development Bank (NADB) and its sister institution the Border Environment Cooperation Commission (BECC) had a mandate that focused on addressing infrastructure needs in water, wastewater, and municipal solid waste. In response to a proposal made by the Mexican government in 1998, the NADB Board of Directors initiated a formal discussion in early 2000 about the desirability of expanding the number of environment-related sectors in which the bank worked, and encouraged public input.

In November 2000 the board decided to add eight categories of infrastructure to its portfolio, while at the same time maintaining a majority of its focus on the original three. The new categories were industrial and hazardous waste, water conservation, water and wastewater hookups for housing, recycling and waste reduction, air quality, public transportation, clean and efficient energy, and municipal planning. The categories of public transportation and clean and efficient energy were understood to be closely related to air quality.

The board and bank staff explored several types of infrastructure projects that would accomplish air quality improvements and decided that its initial lending efforts would be in the area of street paving. Traffic on unpaved streets has been a significant contributor to levels of particular matter in the border region.

Between 2002 and 2005, BECC certified, and NADB gave loans to four street-paving projects. The first was in Agua Prieta, Sonora, in which 17 miles of streets were to be paved at a cost of \$21 million, about 20% of which was supported by a NADB loan (the balance of the financing came from other sources). The second project, in Ciudad Juárez, Chihuahua, was estimated to cost \$14.7 million and the bank contributed a loan of \$5.5 million. The third project was for five communities in Baja California, costing \$65.2 million, with \$27.6 million from NADB, and the fourth was in Nogales, Sonora, costing \$9.7 million, with \$4.8 million from NADB.

BECC and NADB have been reviewing additional street-paving proposals from the municipios of San Luis Rio Colorado, Sonora; Sonoyta, Sonora; Puerto Peñasco, Sonora; Matamoros, Tamaulipas; and Reynosa, Tamaulipas.

NADB intends to obtain and analyze data on PM₁₀ concentrations in *municipios* where paving projects have been implemented to develop evidence that the projects have had the desired effect.

Esfuerzos del Banco de Desarrollo de América del Norte para atender la Calidad del Aire

Arturo Núñez Serrano

RESUMEN

Cuando el Banco de Desarrollo de América del Norte (BDAN) y su institución hermana la Comisión de Cooperación Ecológica Fronteriza (COCEF) se establecieron en 1995, tenían un mandato cuyo enfoque era atender las necesidades de infraestructura del agua, aguas residuales y residuos sólidos municipales. En respuesta a una propuesta planteada por el gobierno mexicano en 1998, la junta directiva del BDAN inició una discusión formal a principios del año 2000 en torno al deseo de expandir el número de sectores relacionados con el medio ambiente en los cuales el banco trabajaba y promovía la participación pública.

En noviembre de 2000 la junta directiva decidió agregar ocho categorías de infraestructura a su cartera, y a la vez manteniendo la mayoría de su enfoque en las tres categorías originales. Las nuevas categorías eran residuos industriales y peligrosos, conservación del agua, conexiones domiciliarias a las redes de agua y aguas residuales, reciclaje y reducción de residuos, calidad del aire, transporte público, energía limpia y eficiente y planificación municipal. Se entendía que las categorías de transporte público y energía eficiente estaban estrechamente relacionadas con la calidad del aire.

La junta directiva y el personal del banco exploraron diversas clases de proyectos de infraestructura que lograran mejoras en la calidad del aire y decidieron que sus esfuerzos iniciales de préstamos serían en el área de pavimentación de calles. El tráfico en las calles sin pavimentación ha sido un contribuyente significativo a los niveles de materia particulada en la región fronteriza.

Entre 2002 y 2005, la COCEF certificó y el BDAN concedió préstamos a cuatro proyectos de pavimentación de calles. El primero fue en Agua Prieta, Sonora, en el cual 17 millas de calles fueron pavimentadas a un costo de \$21 millones, de los cuales un 20% fue auspiciado por un préstamo del NADB (el saldo del financiamiento provino de otras fuentes). El costo del segundo proyecto, llevado a cabo en Ciudad Juárez, Chihuahua, se estimó en \$14.7 millones y el banco contribuyó un préstamo de \$5.5 millones. El tercer proyecto fue para cinco comunidades en Baja California, costando \$65.2 millones, con \$27.6 millones del BDAN, y el cuarto fue en Nogales, Sonora, costando \$9.7 millones, con \$4.8 millones del BDAN.

La COCEF y el BDAN han estado revisando propuestas adicionales de pavimentación de calles de los municipios de San Luis Río Colorado, Sonora; Sonoyta, Sonora; Puerto Peñasco, Sonora; Matamoros, Tamaulipas; y Reynosa, Tamaulipas.

El BDAN pretende obtener y analizar información de concentraciones de PM₁₀ en los municipios en donde los cuales los proyectos de pavimentación han sido implementados para desarrollar evidencia de que los proyectos han obtenido el efecto deseado.

In 1995, the governments of the United States and Mexico jointly established the North American Development Bank (NADB) to finance environmental infrastructure projects certified by its sister institution, the Border Environment Cooperation Commission (BECC). Under the original mandate, both institutions were restricted to addressing the water, wastewater, and municipal solid waste needs of the U.S.-Mexican border region. This chapter describes how that mandate was subsequently expanded to include infrastructure related to air quality and the strategy adopted to address this new category.

The original focus was based on what were considered the major environmental infrastructure challenges resulting from the demographic pressure on the border region. The unmet needs of the water, wastewater, and solid waste sectors posed then were, and

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remain today, the greatest threat to the border region's human health and environment. They present a critical challenge to improving the quality of life of border communities.

In early 1998 the NADB Board of Directors initiated an informal discussion of an expansion of its original mandate in response to a proposal from Mexico's Secretaría de Desarrollo Social (SEDESOL). The NADB board determined however, it would not proceed with the discussion until a reasonable pool of projects, certified by BECC and financed by NADB, could be adequately evaluated and analyzed to determine the bank's success vis-à-vis use of its capital and lending capacity.

By the year 2000, after its first five years of operation, NADB determined that the region would in fact require billions of additional investment dollars to meet water and sanitation needs, reinforcing the convenience of having a bank such as NADB to partially cover such needs. Additionally, new financing facilities and the expansion of NADB's activities would be necessary if it were to expand into additional environmental sectors considered worthy of attention but not included in its original mandate.

Responding to increasing requests by border communities that NADB do more to address a wide variety of infrastructure needs, in 2000 NADB encouraged a public dialogue on how to maximize the use of its capital and lending capacity. The NADB Board of Directors asked management to prepare a detailed report identifying additional sectors that would promote environmentally sustainable development, exploring mechanisms for future financing activities, and assessing the possible expansion of NADB's geographic scope. The NADB board directive was to be implemented using the following criteria:

- Maintain the highest priority for water, wastewater, and solid waste sectors
- Ensure sustainable development criteria are prevalent throughout the expanded scope
- Increase the use of the bank's lending capacity and preserve it to service current and future border needs
- Develop new programs and financing mechanisms to the extent necessary to cover the infrastructure development needs more adequately and expand the geographic scope of the bank

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- Explore ways to provide loans for new types of projects geared toward improving the quality of life of the region's residents
- Expand technical assistance to the communities and the region, particularly in the development of human capital and institutional strengthening, and reinforce the bank's role as financial advisor for the development and completion of projects

After the submission of this report, in November 2000 the NADB Board of Directors authorized NADB to engage in work within additional sectors that would improve environmental conditions in the U.S.-Mexican border region. The sectors were the following:

- Industrial and hazardous waste
- Water conservation
- Water and wastewater connections for housing
- Recycling and waste reduction
- Air quality
- Public transportation
- Clean and efficient energy
- Municipal planning, development, and water

In August 2004, through exchange of diplomatic notes between the governments of the United States and Mexico, an additional change in the original mandate was made with respect to NADB's geographic zone of influence. Originally set consistent with the La Paz Agreement, which defined the border region as the territory within 100 kilometers (km) (about 60 miles) of either side of the international border, the zone was expanded by the new agreement to 300 km on the south side of the border to make BECC and NADB assistance available to some additional Mexican municipalities. North of the border, the boundary of the zone remained at 100 km.

In addition to the explicit inclusion of air quality in this expanded mandate, the bank was aware that two of the other additions—public transportation and clean and efficient energy—were also directly related to a desire to reduce air contaminants. NADB recognized that air quality was a serious problem in several portions of the border region and that there were ways it could help ameliorate this problem through investment in infrastructure. Many of the activities that defined urbanization, and particularly economic

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development, had simultaneously generated emissions, and it was important to reduce these emissions while still encouraging economic growth.

To meet the challenge of improving air quality, NADB established explicit objectives:

- Expedite the improvement of the living standards of the border population in terms of environmental quality, specifically air quality
- Establish mechanisms for sustainable development in terms of air quality
- Facilitate the dialogue, cooperation, and coordination between neighboring communities in addressing their transboundary air quality problems
- Actively partner with the private sector in the implementation of projects aimed at improving the air quality

With this directive from the NADB board, management began to explore ways to address the border's air quality issues. First, some of the activities that led to significant generation of air emissions were identified: inadequate design of roadways that inhibited the free flow and movement of traffic; a large percentage of unpaved streets; a high concentration of old and badly maintained vehicles; long queues of idling traffic at the international bridges; power plants based on fossil fuels, especially coal; open air burning (of brick kilns, dumps, and home fireplaces); paint and body shops; and various industrial, commercial, and residential activities that were not optimized for energy use.

NADB encouraged citizens and local officials to suggest the types of projects that might provide benefits. Examples of solutions included street paving, dedicated commuter lanes in border crossings, proper disposal and recycling of used tires, conversion of brick ovens to natural gas, the San Diego and Arizona Eastern Highway, urban public transport in Ciudad Juárez, urban public transport in Tijuana, and the Arizona Interstate 19 bypass.

NADB reviewed the financial viability of these various project ideas and concluded that the only category clearly feasible for near-term consideration was street paving, because street paving is usually an item in the investment budget of municipalities that can be

used as a repayment source for the bank's loan. Other types of projects, while also important, would require the identification of such a repayment source. A 1999 report prepared by the Arizona Department of Environmental Quality (ADEQ) had cited airborne dust created by vehicles driving on unpaved roads as an important contributor to ambient concentrations of particulate matter (PM) and the resulting respiratory health effects. With this and other supporting documentation, NADB set out its criteria for success with respect to street-paving projects:

- Reduce the possibilities for non-point sources of air pollution
- Increase the financing options for sustainable development, particularly for small communities in the border region
- Reduce the construction and maintenance costs and increase the environmental and financial sustainability of paving activities
- Promote the use of recycled materials, such as used asphalt and tires, in street paving projects

Border communities responded with great interest to this new window for financing at the bank. As of summer 2005, BECC had certified four street-paving projects in Agua Prieta, Sonora; Ciudad Juárez, Chihuahua (Sistema de Urbanización Municipal Adicional); Baja California (Programa Integral de Pavimentación de Calidad del Aire); and Nogales, Sonora.

The Agua Prieta project, certified by BECC in December 2002, encompasses 17 miles of previously unpaved streets. In addition, the project includes the expansion of a four-mile section of Federal Highway 2, which runs through the city, and the construction of three bridges at low-water crossings. Prior to initiation of the project, ADEQ conducted a key study at the request of the project sponsor. The study determined that the selected streets were generating 125 tons per year of PM₁₀ (particulate matter with an aerodynamic diameter of 10 microns or less), and that this could be reduced by as much as 54% (to 57 tons per year) during the first year of the project and to 29 tons per year after the second year (Envair 2002). The total project cost was estimated to be \$21 million. NADB financed

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20% of this amount, or \$4 million. The balance of the project was financed with Mexican federal and state grant resources. Implementation of the project began in August 2004.

A Ciudad Juárez street-paving project, also certified by BECC in December 2002, was designed as a multi-phase effort. The first phase is the paving of 560,000 square meters (m²) of residential streets. According to the BECC certification document, the justification for this project was the direct correlation found in Ciudad Juárez between unpaved streets and a high incidence of respiratory illnesses, combined with a study concluding that in Ciudad Juárez there is a 65% higher incidence of PM₁₀ from unpaved streets than from paved streets (General Directorate of Ecology and Civil Protection of Ciudad Juárez 2002). The total project cost was estimated at \$14.7 million. The proposed NADB financing was \$5.5 million, with additional sources of financing coming from Banco Nacional de Obras y Servicios Públicos (BANOBRAS) (\$5.5 million) and Ciudad Juárez beneficiaries (\$3.7 million). Unfortunately, this project has not begun yet, as the new municipal authorities in Ciudad Juárez have not yet reached a decision about whether they will carry on the project or not.

In April 2003 BECC certified a street-paving project for five communities in the border region of Baja California. The full project would pave 14.9 million m² of residential streets in Ensenada, Mexicali, Playas de Rosarito, Tecate, and Tijuana and the cost is estimated at \$400 million. The cost of the first phase is estimated at \$65.2 million. Thus far, the sponsor is involved in the completion of a first phase, for which NADB has approved a loan. The NADB loan is for \$27.6 million and the balance of the first-phase cost, \$37.6 million, has been provided by Mexican federal and state resources. Implementation of the project began in November 2003. It is expected that the sponsor will continue with subsequent phases over a period of several years.

The most recent BECC certification of a street-paving proposal, in July 2004, was for a project in Nogales. According to the BECC certification document, this project was the result of two studies—first a general study of air quality in the area and then a focused study of unpaved roads—and a workgroup.

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ADEQ, in conjunction with Mexico's Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), worked with the consulting firm ENSR to conduct a binational air quality study in Nogales, Arizona, and Nogales, Sonora (jointly known as Ambos Nogales) from 1994 to 1999 (Heisler, et al. 1999). This EPA-funded study revealed unpaved roads to be one of the main sources of air pollution in Nogales, Sonora. This study led to the formation of a binational workgroup consisting of state and local government officials focusing on identifying and implementing control measures to alleviate the Ambos Nogales air quality problem. This workgroup, which operates under the auspices of the Border Liaison Mechanism (BLM), considers the unpaved road problem a top priority toward improving air quality in the region. Recognizing that resources were likely unavailable to pave all dirt roads in Nogales, Sonora, ADEQ funded a six-week traffic-count study to help identify the roads with the greatest traffic volumes. In general, these were found to be located in the southwest area of the city.

Subsequent to these studies, Nogales, Sonora, pursued funding from different sources for a multi-phase paving project that would pave in total 2 million m² of streets. Following up on the BECC certification, NADB is presently considering financing the first phase. The total cost of this phase, which would pave 300,000 m² of residential streets, is estimated at \$9.7 million and the proposal is for the NADB to provide a loan of \$4.8 million. Additional sources of financing would be BANOBRAS (\$2.24 million) and the State of Sonora (\$2.63 million). NADB staff is in negotiations with the municipio of Nogales regarding the loan's terms and conditions.

BECC and NADB are considering street-paving projects in additional cities for certification and financing, including:

- San Luis Rio Colorado, Sonora
- Sonoyta, Sonora
- Puerto Peñasco, Sonora
- Matamoros, Tamaulipas
- Reynosa, Tamaulipas

The municipio of San Luis Rio Colorado estimates that 76% of its streets are unpaved and is proposing a project to pave approximately 1.6 million m² at a rate of 266,000 m² each year over a

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period of six years. The municipio is seeking NADB assistance (approximately \$6.7 million) through a market rate loan for up to 50% of the total project cost. The municipio anticipates using financial resources from its share of the Puente del Rio Colorado fideicomiso to finance a portion of the total project cost (the fideicomiso is a trust that manages the revenues from the toll-bridge over the Colorado River and distributes those revenues among the municipios of San Luis Rio Colorado, Sonoyta, and Puerto Peñasco).

The Municipio of Sonoyta estimates that 90% of its streets are unpaved. The municipio is seeking a NADB loan in the amount of \$1.9 million to use toward meeting the costs of a street-paving project. The city anticipates using financial resources from its share of the Puente del Rio Colorado fideicomiso to finance the balance.

Similar to Sonoyta, the municipio of Puerto Peñasco estimates 90% of its streets are unpaved. The city has proposed a comprehensive project that would pave up to 96,000 m² at a total cost of approximately \$1.8 million. The city anticipates using financial resources from its share of the Puente del Rio Colorado fideicomiso, which is approximately \$960,000, and is seeking a NADB loan in the same amount to complete the project.

The municipio of Matamoros, with 53% of its streets unpaved, is undertaking a three-phase paving project estimated to cost \$100 million. The entire project would pave 14.3 million m². The first phase will cover 2.8 million m². The municipio anticipates the first phase will cost \$20 million, 50% of which it would seek in an NADB loan. Other sources of funding have yet to be determined for the first phase, but the city anticipates seeking both federal and state funding to complete the financial package.

The municipio of Reynosa is developing a 300 km street-paving project over a three-year period. The municipio is seeking an NADB loan in the amount of \$2.4 million, with additional financing from federal and state resources. The total project cost is currently estimated at \$4.8 million.

Although there is anecdotal evidence that less dust is now in the air in the proximity to completed street-paving projects, NADB intends to obtain and analyze data on PM₁₀ concentrations in municipios where paving projects have been implemented.

Measurable reductions in those concentrations would provide further justification to BECC and NADB for their investments, based on established correlations between such concentrations and respiratory effects among the public, especially in infants, children, the elderly, and those suffering from asthma.

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